Considerations Concerning Measurements Relating to the Urban Design of the Spanish-American City

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Abstract
This paper analyzes the measurements regarding the urban elements used by the Spaniards for the foundation and design of the Spanish-American cities created on the American continent over three centuries during the colonial period. The measurements analyzed are from the urban elements of the plaza, streets, and blocks.

The study was accomplished based on the following: 1) study of the measurements in the theoretical models and in the reticular main cities of Spanish urbanism until the 16th century, 2) study of the measurements in the Laws of the Indies (1573), and 3) by analysis of the measurements used in the cities created on the American continent, through the study of cartography corresponding to the Colonial Spanish period.

In the urban models used during three centuries by the Spaniards on the American continent the use of some particular measurement is evident (besides the common use of urban reticular traces). These measurements have a theoretical and practical base in Spain since the 12th century.

Keywords: Spanish-American city; colonial city; urban measurements; history of Spanish urbanism; urban typology

1. Introduction
Over three centuries, during the urbanization process accomplished by the Spaniards in America, almost a thousand cities were founded. There are currently 911 cities that are known to have been created between 1492 and 1810. Although some had spontaneous origins, most of the cities were designed by urban planning. It is not possible to define one particular model of the Spanish-American city, but in essence we can recognize similar traits in different urban elements, (reticular traces, public spaces or plazas, types of blocks, measurements, etc.).

The purpose of this study is to analyze the measurements used to design Spanish-American cities, even in the different types of cities in which basic measurements can be recognized, and the disposition of the composition of the plaza and its surrounding blocks.

2. Methodology
1) Analysis of the measurements in the main examples of the reticular Spanish cities before the American continent was discovered: (a) measurements of Jaime's II Ordinances (1300), (b) measurements of the Theoretical City of Exiemenis (1385) and (c) measurements of the reticular Spanish cities during the 15th and 16th centuries.

2) Study of the measurements described in the Laws of the Indies (1573).

3) Study of the measurements in the Spanish-American cities, through the analysis of old maps corresponding to the colonial Spanish period on the American continent. Exactly 7,152 images corresponding to cartography from the AGI (Archive of the Indies in Seville) were used as the main database.

3. Historical Considerations of the Spanish-American City
Founding cities was not a very frequent activity for the Spaniards in the 15th century. During this century, the conquerors were superintendents, in charge of the cities. The classic conqueror is described in numerous historical sources as a practical man that, among a thousand heterogeneous activities, created cities by applying knowledge acquired during his personal experience, without having any theoretical background. During the 17th century there was an evolution from a
period of conquest to a period of consolidation of the territory (in the Law of the Indies of 1573 the word conquest is changed to pacification of the Indies), these conquerors, who were high officials, together with the governors promoted the foundation of new cities. The governors (virrey, president, governor) had highly intellectual training and the training of high officials was based on experience, which helped them in getting elected to strategic positions. During the 18th century many cities were founded based on population policy and religious orders.

This ceremony was a tradition imported from Spain. Spaniards in America had a foundation ceremony. Administrative cities. Most of the cities created by the Spaniards in America, from small rural settlements to large and is found in all the Spanish foundations in Spanish-American plazas. The central plaza or main plaza is the ordering element of the urban settlement and is found in all the Spanish foundations in Spanish-America, from small rural settlements to large administrative cities. Most of the cities created by the Spaniards in America had a foundation ceremony. This ceremony was a tradition imported from Spain with a fairly consistent form during three urbanization centuries on the American continent. However, the process of founding the city in Spanish America lacked continuity and hardly possessed similar aspects as those created in the medieval cities of Spain. The biggest difference is that in the Spanish-American process, the creation of the city was accomplished from a centralized and modern political system, and with a very concrete territorial occupation policy. The steps to founding the cities included:

1) Election of the site. In most cases the election of the place was influenced by the experience of the indigenous peoples in choosing their settlements. The criteria for selection was basically: (1) Abundance of natural resources, (2) Healthy climate, (3) Consideration of the prevailing winds, (4) The celestial constellation and (5) The orientation to the sun.

2) The name. Since the arrival of Columbus in 1492, the new continent was renamed by the Europeans: as were seas, ports, gulfs, rivers and mountains etc. A study of the names of the newly founded cities helps us to understand the personality of the founders, their experiences and beliefs, and even their feelings. As such, the names of the new foundations can be classified into three main groups: (1) Names of Spanish origin: Spanish places (the founders used the names of their own towns and places of origin), names related to the king or to the Spanish government, the founder's own names, their lovers names and religious names, (2) names in indigenous native languages, (3) mixed names.

3) Delimiting the Plaza. Normally on the same day as the statement of the takeover of the territories, the delimiting of the square was carried out. The dimensions of the plaza establish the geometric dimensions of the urban trace. In the middle of the plaza is placed the Rollo as a symbol of the city. When a city had to be moved (which occurred frequently) the neighbors took the Rollo to the place of the new plaza.

4) Election of the plot for the Church. After the delimiting of the plaza, the place of the church was selected. A cross was erected in the selected place, and the first religious ceremony was celebrated.

5) Plot of the Cabildo (council). The self-governance of the community was of great importance. Thus, the figure of the Cabildo was very important for the foundation of the city. After selecting the plot for the church, the plot for the Cabildo was selected.

6) Plot of the neighbors. The following step was division of the blocks and allotment of plots. The most important citizens got first choice of their plots next to the plaza. The rest were distributed randomly among the other neighbors. In the first foundations the blocks were split into four parts, composed of blocks of around 3,000 sq. m. and cities with low density.

7) Map of the city. Together with the foundation record, a drawing was made representing the trace
of the city and sometimes the land assignment of the inhabitants. This graphic representation had a great administrative, political and urban value. The foundation plans reflected the form of the city, being the plaza and generating element as the cities' geometric and symbolic center.

4. Spanish Urban Measurements during the 14-16th Centuries

4.1 The Ordinances of Jaime II (1300)

In the year 1300, for the first time a city was proposed as a model for the creation of new settlements through the initiative of the king of Mallorca, Jaime II. This model (Fig.2.) was designed for a population of 100 families. Each family had one plot for housing construction and another for cultivation. The urban parceling unit was known as a cuartón⁵, and the cultivatable surface around the outside of the city measured five cuarteradas⁶. Sometimes 10 cuarteradas were designated for use by cattle. The city streets had dimensions of three brazas reales⁷ (6.36 meters). In the Ordinances there is neither a reference to the plaza nor to the church, although in the documents drawn up for the foundation of the city of Felan a plaza is described which had an arcade that measured 10 palmos⁸ in width. According to these dimensions, the tracing of the cities of King Jaime II was basically composed of square blocks, each of which measured 100 x 100 varas. Fourteen settlements were established, but the great majority of them were founded on existing settlements, which were of irregular tracing. Only the cities of Sa Pobla and Petra (Fig.2.) maintained the trace of the Ordinances.

4.2 The Ideal City of Exiemenis (1385)⁹

In 1385 the first written city theory that appears in Spain is the work of Francesch de Exiemenis (1349-1412). Between the year 1384 and 1385, Francesch de Exiemenis wrote Dotzé del Crestía¹⁰, in which is contained Theory of the Ideal City where the measurements of square blocks were defined in 1,000 pasos¹¹ (1.393 meters) along their sides.

4.3 Spanish cities until the 15-16th century¹²

(1) In 1477 Chipiona (Fig.2.) was created, with a linear and parallel trace. A plaza was established in the interior with the council and the church. The plots were very large for the time, with dimensions of 140 varas (120 meters) by 70 varas (60 meters). (2) In 1483, the Catholic Kings founded Puerto Real (Fig.2.), with the most regular trace to date. In its interior, two blocks were left unconstructed to create two plazas, in which were located the church and the council. The sizes of the blocks were between 90 x 50 varas (80 x 46 meters) and 130 x 80 varas (100 x 58 meters). (3) Sanlúcar de Barrameda (Fig.2.) was founded at the beginning of the 14th century, with a similar trace to Puerto Real and Chipiona. (4) The city of Santa Fe (Fig.2.) was built as a military camp in 1491, during the conquest of the city of Granada. The perimeter of the wall and pit drew a perfect rectangle guided to cardinal points. Nicolás de Ovando participated in the foundation of Santa Fe, and years later founded the city of Santo Domingo, the first regular trace city on the American continent. The square shape, an urban model in Spain, was not interrupted in the 15th century, with numerous plots traced in perfect squares, for example: (5) Villamartín (1502), (6) Paterna de Ribera (1503) or (7) Mancha Real (Fig.2.).

5. Measurements of the Laws of the Indies (1573)

The Laws of the Indies were written documents in which the geometry of the urban models was not well defined. There are several instructions about the construction process for a new city, but there is not much information regarding geometry and size.

According to the criteria of García Fernádez¹³, it is possible to study the geometric urban form based on

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Fig.2. Spanish Urban Measurements, 14th-16th century
five measurements (Fig.3.), described in The Laws of the Indies, as follows: According to the dimensions of the plazas described in The Laws of the Indies, three sizes of cities, with modules of 6 x 6 blocks and squared blocks could be configured. (1) Type A: Plaza of 200 x 300 feet (55.7 x 83.6 meters), modules of 6 x 6 blocks. (2) Type B: Plaza of 400 x 600 feet (111.4 x 167.2 meters) which is a good proportion according to The Laws of the Indies. (3) Type C: Plaza of 530 x 800 feet (147.7 x 222.9 meters). According to the two parceling units described, two more modules could also be configured: (4) Type D: plot divisions of five Peonies (381sq. m), (5) Type E: plot divisions of three Cavaleris (1,143 ha).

According to the plaza shapes described in the Laws of the Indies, traces of cities with only square blocks are not possible.

6. Analysis of the Urban Measurements in Spanish-American Cities

By analyzing AGI cartography the principal measurements used in the design of Spanish-American cities, and their influence on the length of the blocks, the urban traces and the form of the plaza have been studied. From the map’s data, only those cities with a reticular grid have been selected. Cities with irregular traces were discarded, since it is considered that they were not the product of a design a priori, but of natural urban growth, conditioned by the geography of the land. In the AGI cartography there is only one city with a radial trace (Nueva Paz, AGI- Mapas y planos de Santo Domingo, 650), which was also discarded.

6.1 Database, selection of the city maps

The AGI cartographic is a compound of 7,152 microfilms, which have been classified into eight groups: (1) Geographic general (interior and maritime maps), (2) Geographic-military (reflected the geography of the place with the intention of safeguarding and controlling the territory), (3) Geographic-project (reflected different designs of engineering projects such as territory network, ports, bastion roads, (4) Urban project (descriptive plans of existing cities), (5) Urban general (city designs or urban infrastructure designs), (6) Architectonic project (buildings or urban spaces), (7) Details (architectural or urban project elements), (8) Others.

The total of urban project and urban general maps is 354 (Table 1.). Within this group, the original plans of only those cities built by Spaniards were selected (which reduces the number of maps to 339). In cities with repeated maps, the original plan was selected, together with maps with a good definition level. Therefore the study was carried out on 110 city maps, (of which only 85 cities had defined measurements).

6.2 Definition of measurements

The plaza Mayor is the fundamental element of the Spanish-American city. It defines the downtown area: the geometric and generating center from where the trace of the city is organized. It is the vital and symbolic center and a gathering point for all social...
functions (political administration, justice, trade and celebrations). The plaza is an element of the grid. It is unfixed and also the result of leaving one or more empty blocks. In the plans of the AGI, there is no single city without a main plaza. Three main measurements are required to define the space of the plaza (and its surrounding blocks) during the foundation process (Fig.4.), including: block measurements (a, b) and street measurement(s).

6.3 Definition of measurement units
The maps and plans of the AGI were accomplished by very different units that depended on the period and region where they were created, and the origin of their designers. From analysis of the maps 21 different types of measurement unit were found: Cordel\textsuperscript{16} (Cord), Grados (Degrees), Legua\textsuperscript{17} (League), Legua Americana\textsuperscript{18} (American League), Legua Castellana\textsuperscript{19} (Castilian League), Legua Española\textsuperscript{20} (Spanish League), Legua Francesa\textsuperscript{21} (French League), Legua Inglesa\textsuperscript{22} (English League), Legua Marina\textsuperscript{23} (Marine league), Milla Marina\textsuperscript{24} (Marine Mile), Paso (Step), Pie (Feet), Pie Castellano\textsuperscript{25} (Castilian feet), Pie Francés (France feet), Pie de Paris (Feet of Paris), Pie de Rey (King feet), Toesas\textsuperscript{26}, Varas, Varas castellanas, Varas Reales and Mexican Varas.

During analysis the chosen unit of measurement was the VARAS (equal to 0.836 meters). Varas was the most widely used unit in the AGI city plans.

6.4 Definition of Plaza types
According to the shape of the plaza and its relation to the streets originating from it, the plans of AGI were divided into six different types: (1) Plaza type A: from its corners (and aligned with the facades of the plaza) eight streets originated. This was the result of leaving a block unbuilt. Its area is \((2s+a) \times (2s+b)\) square varas. (2) Plaza type B: from its corners (and aligned with the facades of the plaza) eight streets originated, and perpendicular to the middle point of two of the facades of the plaza another street was formed. In such a case a total of ten streets gave access to the plaza. The design of this plaza was the result of converting two blocks into a public space. Its area was \((2s+a) \times (3s+2b)\) square varas. (3) Plaza type C: from its corners (and aligned with the facades of the plaza) eight streets originated and, perpendicular to the middle point of four of the facades of the plaza another street is formed. In this case a total of twelve streets gave access to the plaza. The design of this plaza was the result of converting four blocks into a public space. This type of plaza is defined in the Law of the Indies. Its area is \((3s+2a) \times (3s+2b)\) square varas.

(4) Plaza type D: from its corners (and aligned with the facades of the plaza) eight streets originated and, also perpendicular to the middle point of two of the facades of the plaza another street was formed, while another two streets were formed from the other two facades. In this case a total of fourteen streets gave access to the plaza. The design of this plaza was the result of converting six blocks into a public space. Its area is \((3s+2a) \times (4s+3b)\) square varas. (5) Plaza type E: from each of its four facades (in the middle point) one street originates. This is a plaza with only four streets.

<table>
<thead>
<tr>
<th>NUMBER OF MEASUREMENTS</th>
<th>BLOCKS FORMS</th>
<th>CITY FORMS</th>
<th>PLAZA FORM - STREETS TYPES</th>
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<td>2 measurement (a, b)</td>
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<td>A 51</td>
<td>B 1</td>
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<td></td>
<td>RECTANGLE</td>
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<td>E 4</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>OTHERS F 4</td>
</tr>
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Fig.4. Creation of the plaza. Main measurements (a, b, s) in the square and rectangular trace

Fig.5. City types
It was a design in which the trace was maintained because the form of the plaza was obtained inside four polygonal blocks of six sides each, creating a closed corners plaza. (6) Plaza type F: Other cases of unusual shapes.

6.5 Resume of analysis

6.5.1 Cities with two measurements (a) and (s)

In such case a = b. These types of city had only square blocks (axa) in their urban traces. There are a total of 64 cities with these characteristics; 51 with Plaza type A, one with Plaza type B, four with Plaza type C, four with Plaza type E, and four with Plaza type F. The measurement (a) of the square blocks most commonly used was 100 varas (16 cities), followed by 150 varas (11 cities), 80 varas (5 cities), 138 varas (4 cities), 140 varas (4 cities), 200 varas (4 cities) and 75 varas (2 cities). The remaining measurements using only one were 35, 55, 90 and 120 varas. There are 14 cities without defined measurements (Fig.6.).

6.5.2 Cities with three measurements (a), (b) and (s)

There are a total of 46 cities created by three main measurements. Their urban traces can be divided in half:

1) Cities with only rectangular blocks (axb) in their urban traces total seven. There are two cities with Plaza type A, one with Plaza type B and four with Plaza type F. The measurements 80, 90, 100 and 150 varas were used in two cities each. The measurements 10, 15, 20, 23, 35, 50, 90 and 140 were used only once (Fig.7.).

2) There are a total of 39 cities with square blocks (axa) and rectangular blocks (axb) in their urban traces. Six cities in which a plaza was designed surrounded by a square block, three cities in which a plaza was designed combining both square and rectangular blocks. The measurement most often used was 100 varas (19 cities) and 200 varas (13 cities), followed by 40 and 80 varas (4 cities), 20 varas (3 cities), 35, 44, 45, 50, 55, 65, 70, 75, 92, 110, 140, 175 and 212 varas (1 city) (Fig.8.).

Of the total cities (Fig.9.), four measurements (a or b) were commonly used: 100 varas were used in 37 cities (44%), followed by 200 varas in 17 cities (20%), 150 varas in 13 cities (15%) and 80 varas in 11 cities (13%). The rest of the measurements were 10, 15, 20, 23, 35, 40, 44, 45, 50, 55, 60, 65, 75, 90, 92, 110, 120, 138, 140, 175 and 212 varas.

Fig.6. Measurements of cities with square blocks only

Fig.7. Measurements of cities with rectangular blocks only

Fig.8. Measurements of cities with square and rectangular blocks

Fig.9. Measurements in the Total Number of Cities
6.5.3 Measurement of streets

The measurement most commonly used was 12 varas (33 cities) and 10 varas (28 cities), followed by 15 varas (10 cities) and 11 varas (6 cities). Measurements such as 8, 20, 23 and 40 varas were less frequently used (1 city each).

7. Conclusion

Measurements used in the urban design of Spanish-American cities had a theoretical and practical base in Spain since the 12th century. The measurements and models created by Jaime II in 1300 for the new settlements of Majorca could have been the base for the theoretical model that Exiemenis wrote in 1381. Until the 16th century the 100 varas measurement of the square and rectangular blocks was the most frequently used in Spanish cities with geometric traces.

Most of the cities founded by Spaniards on the American continent were created by geometric trace and standard measurements. Cities created using only two measurements (one block measurement and one street measurement) were most common. Consequently the urban trace with only square blocks is the most used. In the vast majority of these settlements the plaza is a perfect square. The street measurement most used is 14 varas and the block measurement is 100 varas (around 86 meters).

Variations of the standard measurement (100 varas) are 200 and 150 varas, cities created by three measurements (two block measurements and one street measurement), whose characteristics are urban traces with only rectangular blocks or traces with the combination of the square and rectangular blocks, and variations in the designs of the plazas.

The Laws of the Indies were not an accurate description of the measurements of the Spanish-American city. In all the AGI maps, even those of all the settlements created on the American continent, no geometry has been found that corresponds to the five possible types described by the Laws of the Indies.

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References


2) The Law of the Indies (1573), book IV, title 5, laws VI and VII.


5) Rollo: Monument of stone column.

6) Cuarton: Old Spanish measurement with a surface equivalent to a square of 42.12 meters on its side, and an area of 1.775 m2.

7) Cuarterada: Old Spanish measurement with equivalent surface to area of 7.103 m2.

8) Brazas reales: Old Spanish measurement of longitude equivalent to 2.12 meters. Used in the navy it equals two rods, approximately 1.6718 meters. In the Philippines it is used as an agrarian measurement of 2 centimeters and 9 millimeters.

9) Palmos: Old Spanish measurement of longitude equivalent to 2.12 centimeters, fourth part of a rod, and it is supposed that it is equal to the length of the open hand of a man.


12) 1 Pasos: Step = 5 feet = 1.593 meters.


15) Classification of the Archives of the Indies maps and images is divided into 30 sub-sections, on several themes and areas, the names of which correspond to the old political division of the American continent during the Spanish colonial period. The American continent maps are found only in sub-section 1) America Generale, 2) Buenos Aires, 3) Florida y Luisiana, 6) Guatemala, 7) Mexico, 8) Panama, 9) Peru y Chile, 10) Santo Domingo and 11) Venezuela.


17) 1 Cordel: 5 steps.
18) 1 Legua = 20,000 feet = 6,666 2/3 varas = 5.572, 7 meters.
19) 1 Legua americana: 3,000 steps = 2.179 meters.
20) 1 Legua Castellana: 4.190 meters.
21) 1 Legua Española = 5.572, 7 meters.
22) 1 Legua Francesa = 4.444 meters.
23) 1 Legua Inglesa = 4.827 meters.
24) Legua Marina = 5.555, 55 meters.
26) Pie Castellano = 0.302 meters.
27) Toesas = 1.946 m.