Confronting Vitruvius: a geometric framework and design methodology for Roman rectangular temples

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Studies of design principles of Roman temples typically have been based on Vitruvius, which inspired a belief that the colonnade was at the core of the geometric framework of every temple and that the lower column diameter (D) was used as a module to plan all other aspects, both horizontally and vertically. Archaeological evidence, however, shows that most extant temples do not match the Vitruvian model.[1] Scholars have tried to explain the discrepancies in different ways: for example, by claiming that Vitruvius did not describe the actual state of Roman architecture but "what it should be",[2] that architects had to make "adjustments" to the "Vitruvian ideal" to create a particular effect, or that they had to make on-site corrections.[3] A few studies have shown that also other design principles must have been at play. P. Barresi, based on the geometric analyses of several temple-podia of the 5th to 1st c. B.C. in central Italy, argued that they were designed and built relative to a square grid.[4] He derived the size of each grid-module from the proportions of the rectangles of the temples' bases. He later reached the same conclusion for the temples of the Capitolium at *Sufetula*,[5] while J.-N. Bonneville presented a similar theory for temples at *Baelo Claudia*.[6] M. Wilson Jones observed that the principal parts of the façades of the Temple of Portunus at Rome and the Maison Carrée at Nîmes formed square contours,[7] which he considered a reason for the "irregularities" (relative to Vitruvian principles) in the intercolumniations. He also presented other examples of simple geometric shapes in the compositions of the façades of Roman buildings.

Building upon these studies and on my previous research of the geometric framework of Roman theaters,[8] the present article presents a possible theory for a specific design methodology. A geometric analysis of *c.*30 extant structures seems to show that Barresi's grid theory was not unique to just the temples in his study, but that many more podia were laid out relative to a square grid that was based on simple modules of 8 or 10 RF (Tables 1, 3, 8 and 9; figs. 1 and 5). Wilson Jones' observations are not limited to his examples; the façades of all temples in my study were probably based on the same grid-module, as well as on the principle that their main part was enclosed within a square contour, which I refer to as the "rule of the square". In addition, I argue that every dimension and proportion of the elevation was established by dividing the height to the top of the cornice (or "cornice line") into 6 to 8 segments, which I call *H(e)*. One part was always used for the entablature and the

1 M. Wilson Jones, *Principles of Roman architecture* (Cambridge 2009) 64-68; I. D. Rowland and T. Howe (edd.), *Vitruvius. Ten books on architecture* (Cambridge 1999) 15.

2 Rowland and Howe ibid. 15-17.

3 Wilson Jones (supra n.1) 38-39.

4 P. Barresi, "Schemi geometrici nei templi dell'Italia centrale," *ArchCl* 42 (1990) 251-85.

5 Id., "I *capitolia* di *Sufetula* e di *Baelo Claudia*: analisi dei progetti," in A. Pizzo, H. Dessales and S. Camporeale (edd.), *Arqueología de la construccíon*, I. *Los procesos constructivos en el mundo romano: Italia y provincias occidentales (*Consejo Superior de Investigaciones Científicas 50, 2009) 3-12.

6 J.-N. Bonneville *et al.*, *Belo,* VII. *Le capitole* (Madrid 2000) 155-79.

7 Wilson Jones (supra n.1) 65-68.

8 W. Fuchs, "The geometric language of Roman theater design, part 1," and "The geometric language of Roman theater design, part 2," *Nexus Network Journal* 21 (2019) 547-90.

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podium almost always equated to 1.5 times that height. The flexibility in further subdividing this module explains the richness of proportions registered in Roman temples.

The temples in this paper were selected mostly for their state of preservation and the availability of reliable documentation; further, a wide range of locations and construction dates is necessary to identify general principles rather than geographically distinct or transient fashions. I focus on 4 temples in considerable detail: the Temple of Portunus at Rome (*c*.120 B.C.), the Maison Carrée at Nîmes (end of the 1st c. B.C.), the Temple of Augustus and Livia at Vienne (early 1st c. A.D.) and the Temple of Trajan at Pergamon (first half of the 2nd c. A.D.). The analysis of a further *c*.30 temples corroborates the conclusions presented here to the degree that their surviving evidence allows it (Tables 8-9).

This study does not presume that there was one single, consistent design methodology of temples throughout the Roman period. More probably a general approach existed or, as it is called today, an "open system of design",[9] with a plethora of flexible parameters that allowed architects to create the observable richness of proportions within the constraints of an archetype. We can consider in a similar manner, for example, Corinthian capitals: no two are completely identical and many do not have the same proportions, but they are all called by the same name and it is assumed that they were designed according to a set of principles, some of them constant, others changing depending on the project. To consider temples' richness in variations within a general definition, it is necessary to delve deep into the geometric framework to uncover underlying principles. It is also essential to acknowledge the ambiguity of translating a geometric scheme into classical architectural forms expressed in stone, brick or concrete — in other words, a line or a mathematical ratio could be applied on either side of a wall, its axis or the edge of a wall's base. There were probably no absolute rules that compelled designers whether to, for example, use the structural axis of columns or a wall as a primary datum; instead they must have had individual preferences and methods.

TABLE 1
MODULAR DIMENSIONS OF TEMPLES BASED ON A 10-RF GRID
(all dimensions in RF)

Temple	*Front no. of columns*	*Width*	*Vert. align. podium grid*	*Podium length*	*Podium length with wing walls*
Portunus, Rome	4	40	Plinth	70	80
Juno, *Gabii*	6	60	Walls	80	90
Diana, Mérida	6	60	Plinth	100	unknown
In Foro delle Corporazioni, Ostia	4	40	Walls	70	80
Trajan, Pergamon	6	60	Walls	90	*c*.105
T. Jupiter, Ostia	6	60	Plinth	95	120

The case-studies

Of the 6 temples in Table 1 and fig. 1, four are hexastyle with a podium width of 60 RF.[10] Their lengths range between 80 and 120 RF, which in three cases were multiples of 10. The

9 A. P. Sage, *Systems engineering* (New York 1992) 168: "In open systems architecture (of design) the design includes (intentional) provisions to make it possible to expand or modify the system at a later stage after initial operation".

10 Most dimensions in this paper are in Roman ft (RF), where 1 RF = 0.296 m.

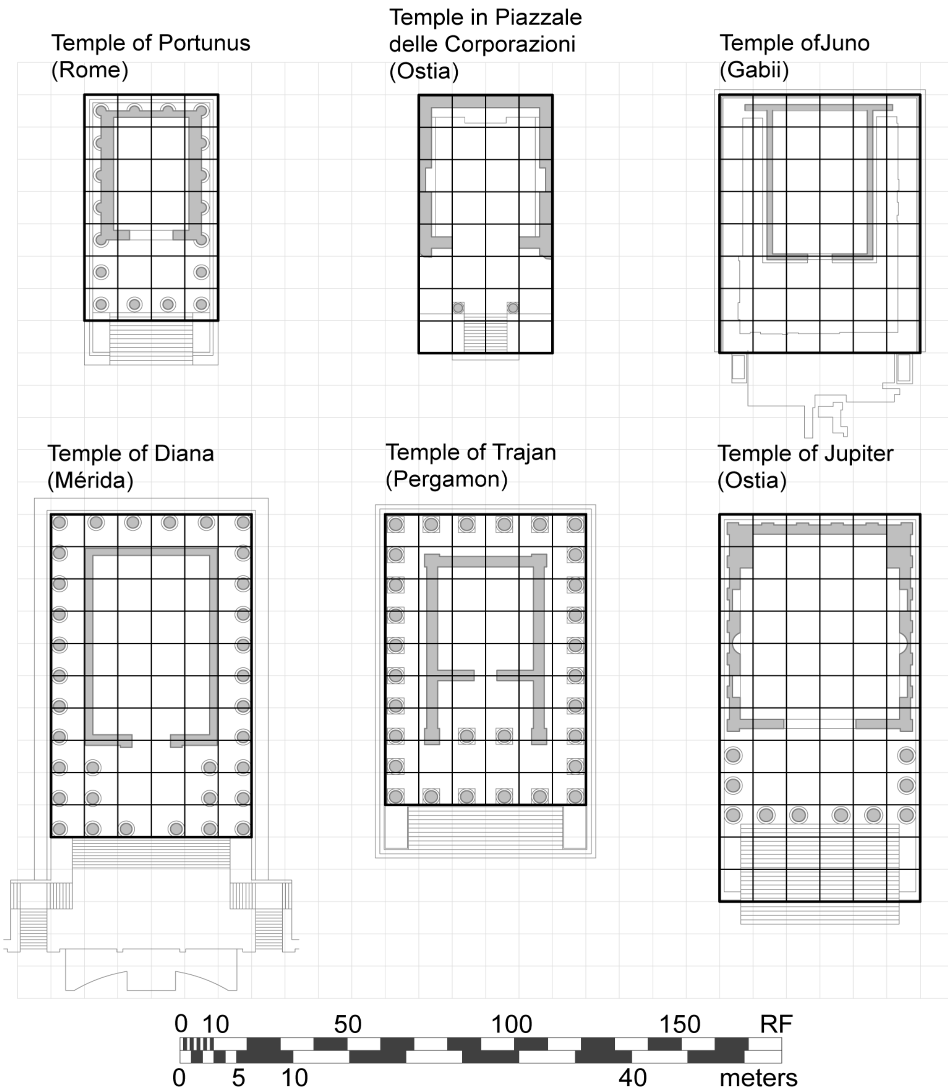

Fig. 1. Selected examples of temples based on a 10-RF geometric grid (author).

podia of the other two — tetrastyle — temples were 40 RF wide; both their lengths were 80 RF when including the walls flanking the steps and 70 RF without. In 3 temples these widths were aligned with the outside faces of the walls, in the other 3 with the extents of the podium plinth (Table 1 and fig. 2). These principle dimensions based on multiples of 10 and a correlation between the number of façade columns and the number of 10-RF segments in the overall width (e.g., a tetrastyle design with a 10-RF module translated into a width of 4 x 10 RF = 40 RF) make extremely probable the use of a bi-directional 10-RF grid during the design process. However, other than this, the structures have little in common. They were built at different times, in different provinces, with different sizes, and had different forms — peripteral, pseudoperipteral and *peripteros sine postico*. Column diameters and intercolumniations were unique in each structure. The design of the side colonnades (or the semi-columns in pseudoperipteral temples) does not follow Vitruvian guidelines and demonstrates even greater diversity: e.g., the Temple of Portunus has 7 columns and 7 grid-segments, while the latest reconstruction of the Temple of Trajan at Pergamon shows

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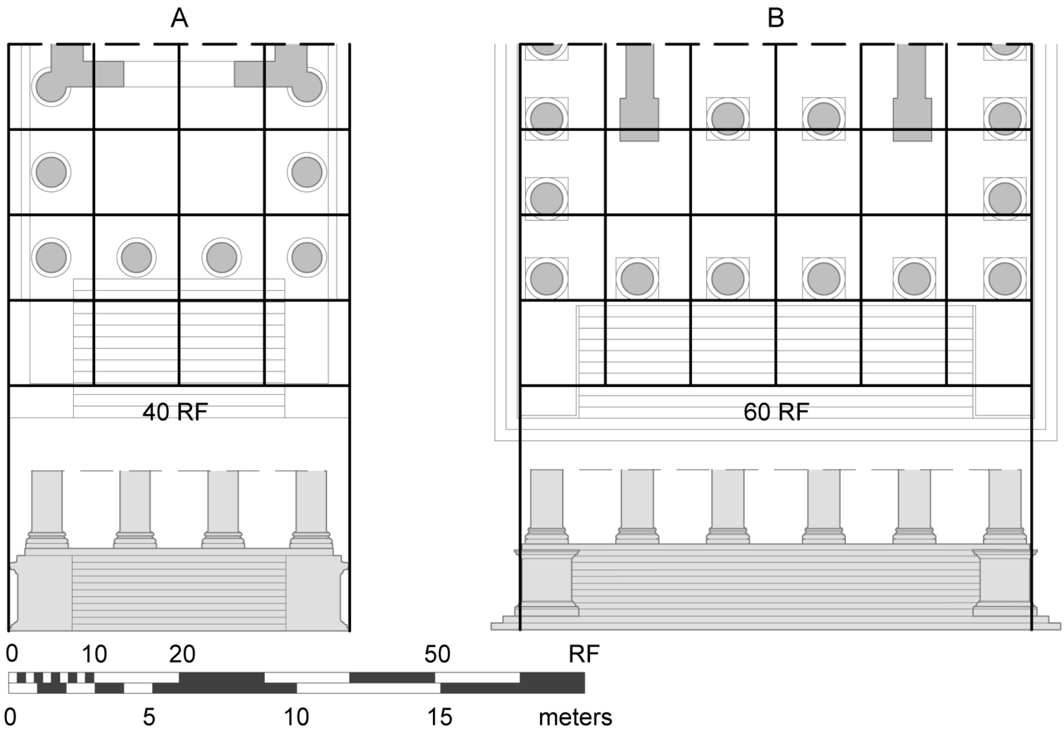

Fig. 2. Two types of alignment of the layout grid with the podium. A: Temple of Portunus, Rome — the extents of the grid are aligned with the plinth of the podium. B: Temple of Trajan, Pergamon — the extents of the grid are aligned with the outside faces of the podium walls (author).

10 columns distributed over 9 modules.[11] The interaxial distances between columns must have been based on design objectives that cannot be recognized in plan only: they had to be studied by the architects in the elevation views (Vitruvius' *ichnographia*).[12]

TABLE 2
PROPORTIONAL SYSTEM OF THE TEMPLE OF TRAJAN IN PERGAMON AND THE VITRUVIAN STANDARD

	Vitruvius	*Temple of Trajan*
Overall plan (width to length)	1 : 2	1 : 1½ (colonnade) ~1 : √3 (podium with walls flanking the steps)
Intercolumniations	1 : 1½ (pycnostyle), 1 : 2 (systyle), 1 : 3 (diastyle), 1 : 2¼ and 1 : 3 (eustyle)	1 : 2 (front – axis) 1 : 1⅚ (front – sides) 1 : 1½ (sides – Nohlen) 1 : 1⅚ (sides – Stiller)
Column proportions (Corinthian)	1 : 10	1 : 9
Entablature height : column height	1 : 4 (assuming the frieze is decorated)	~1 : 5⅖

11 K. Nohlen, "Ein Tempel für den Kaiserkult – Das Trajaneum von Pergamon," in R. Grüßinger, V. Kästner and A. Scholl (edd.), *Pergamon. Panorama der antiken Metropole* (Petersberg 2011) 159-60.

12 Wilson Jones (supra n.1) 64-65 talks about "the dialogue between the plan and elevation".

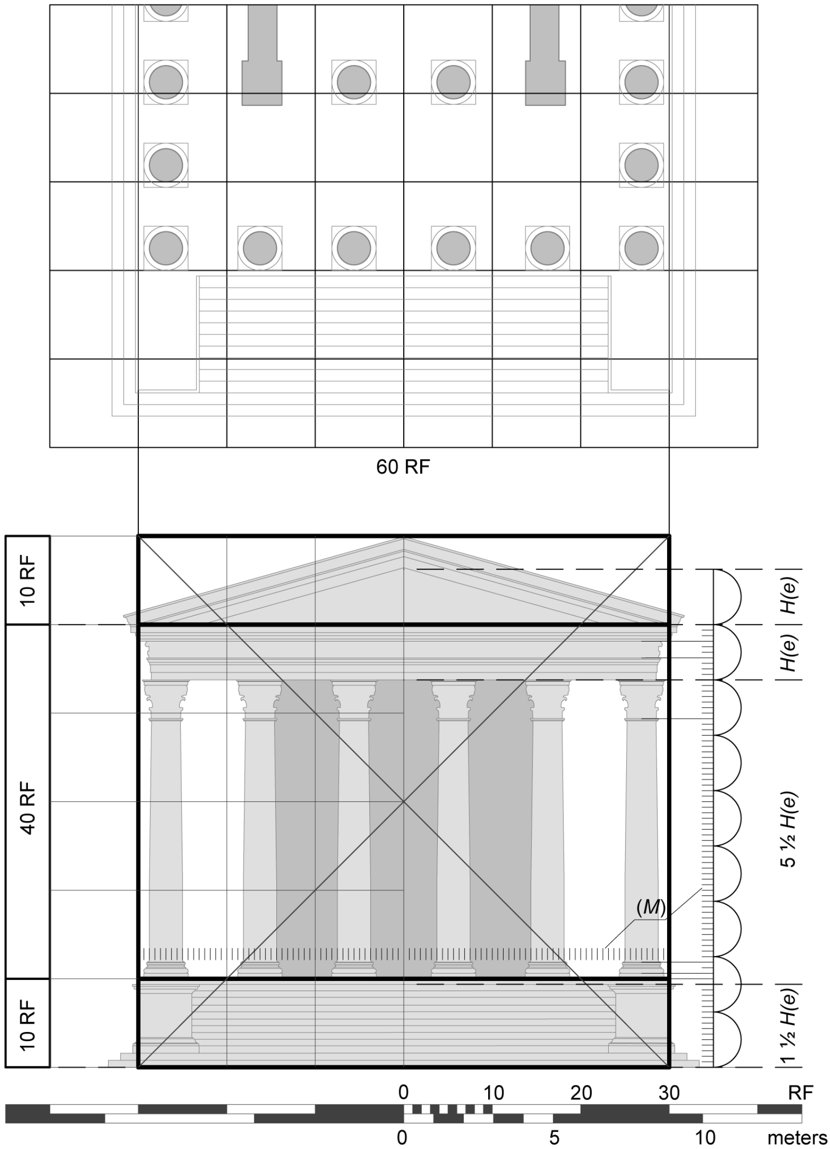

Fig. 3. Analysis of the composition of the façade of the Temple of Trajan at Pergamon (author).

Temple of Trajan, Pergamon

Plans and elevations of the Temple of Trajan have been reconstructed with a great degree of certainty.[13] The principal ratios present significant divergences from Vitruvian guidelines (Table 2). The present study, however, identified a system of mathematical and geometric relationships that unified all measurements into a single scheme, based on the same 10-RF grid as the podium. The façade forms a square (60 x 60 RF) which is divided vertically into 3 parts, the height of each of which is a multiple of the grid-unit: 10 RF for the podium, 40 RF for the colonnade (including entablature) and 10 RF for the pediment (fig. 3). I argue that from the bottom of the podium to the cornice line the building was

13 The measurements used here are those of H. Stiller, *Das Traianeum* (Altertümer von Pergamon V.2, 1895). See also Nohlen (supra n.11).

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further divided into 8 equal segments or *H(e)*, defined by the height of the entablature of $6^1/_4$ RF: 1 *H(e)* for that same entablature, $5^1/_2$ for the colonnade with stylobate, and $1^1/_2$ for the podium (the pediment will be discussed later). Both the 10-RF unit and the *H(e)*, however, were too large to help with the design of smaller elements. A study of the measurements of the architectural details shows that their largest common denominator was $^5/_8$ RF or exactly $^1/_{10}$ of the *H(e)*. Since it is the closest to Vitruvius' concept of a module, I will refer to it as such in this article, or simply *(M)*. In this temple, for example, the architrave of 4 *(M)* with the frieze and cornice, each 3 *(M)*, total 10 *(M)* or 1 *H(e)*, while the lower diameter of the columns is 6 *(M)* ($3^6/_8$ RF), the height of the capitals is 7 *(M)* ($4^3/_8$ RF), the plinth is 1 *(M)*, and the base is 3 *(M)* (or $^1/_2$ D).

The clever design is further confirmed by the coordination between all base units of the proportional system:
1) the large unit is 16 *(M)* (16 x $^5/_8$ RF = 10 RF);
2) the height of the entablature is 10 *(M)* (10 x $^5/_8$ RF = $6^1/_4$ RF);
3) the combined height of podium, colonnade and entablature was 80 *(M)* (50 RF / $^5/_8$ RF = 80);
4) the height and width of the façade was 96 *(M)* (60 RF / $^5/_8$ RF = 96).

In short, it appears that the architect used a 3-tiered system of modularity, starting from whole numbers for the principal square contour (60 RF) and the top of the cornice (50 RF). Dimensions of the major elements were then harmonized relative to the height of the entablature, *H(e)*, while a $^1/_{10}$-fraction of *H(e)* was used for the small-scale components. In this way, the principal postulate of Vitruvian *symmetria* (3.1.9) was realized:

> (…) then it is left for us to recognize that the ancients, who also established the houses of the immortal gods, ordered the elements of those works so that, in both their shape and their symmetries, fitting dimensions of separate elements and of the work as a whole might be created.[14]

One particular element shows both the architect's creativity and the flexibility of this intricate system of interlocking dimensions and proportions: the podium was 10 RF in one system when including the stylobate, but $1^1/_2$ *H(e)* or 15 *(M)* in the other system without it. For the colonnade to be exactly $5^1/_2$ *H(e)* or 55 *(M)*, however, it also needed to include the 1 *(M)*-high stylobate (fig. 3). The architect at Pergamon was not unique in his approach, however: analysis shows that other Roman architects also considered the stylobate to be separate from the podium[15] and Vitruvius (3.4.5) presents it almost as a self-evident statement:

> But if there will be a podium on three sides of the temple it should be constructed so that the plinth, base molding, dado, cornice and *lysis* fit the stylobate beneath the column bases.[16]

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14 ... *eos qui etiam aedes deorum inmortalium constituentes ita membra operum ordinaverunt ut proportionibus et symmetriis separatae atque universae convenientes efficerentur eorum distributione.* All English translations of Vitruvius in the paper are from Rowland and Howe (supra n.1).

15 My research has shown that the stylobate was included in the height of the colonnade in the temples of Mars Ultor (3-step stylobate) and Apollo Sosianus (1-step stylobate) and the Maison Carrée (1-step stylobate). In the Temple of Augustus and Livia at Vienne there is no stylobate. In the temples of Portunus at Rome and Augustus at Pola it could be part of either the colonnade or the podium, given the variance in the measurements (see below).

16 *Sin autem circa aedem ex tribus lateribus podium faciendum erit, ad id constituatur uti quadrae spirae trunci coronae lysis ad ipsum stylobatam qui erit sub columnarum spiris conveniant.*

The reconstructed height of 10 RF of the temple's partially preserved pediment is seemingly inconsistent with the proportional system of the front elevation, as its closest round value would be $1^1/_2$ *H(e)* or $9^3/_8$ RF. However, Vitruvius (3.5.12) again provides a probable explanation for the irregularity as he singles out the *tympanum* from the rest of the pediment:

> The height of the *tympanum* in the gable should be made such that the entire front of the cornice (*corona*), from the outermost molding (*cymatium*), is divided into nine parts … The raking cornices above should be placed in the same way as the lower, except for the simas.[17]

Most probably this means that the height of the *tympanum* was designed as 1 *H(e)* of $6^1/_4$ RF, with the *corona* and the *sima* separately above it (fig. 3). The same process is observed in all 4 case-studies: the modular height based on *H(e)* was applied to the *tympanum* (although sometimes with the *corona*), but the height of the *sima* was added separately.

The intercolumniation of the temple's colonnade too does not follow any of the standard Vitruvian systems, nor is it aligned with the 10-RF grid. In addition, the columns' diameters (or their halves) are not small enough to be used as a module for designing architectural details. Both, however, can be explained through *(M)*. The interaxial distance between the two central columns is 18 *(M)* or $11^1/_4$ RF; that between those on the sides is 17 *(M)* or $10^5/_8$ RF. The columns' lower diameter is 6 *(M)* or $3^3/_4$ RF. The actual intercolumniations are thus 12 *(M)* (2 D or $7^1/_2$ RF) and 11 *(M)* ($1^5/_6$ D or $6^7/_8$ RF) (fig. 3). This design follows Vitruvius' eustyle (3.3.6-7), characterized by the wider opening between the columns on the axis of the temple than between those on the sides; however, the difference between both intercolumniations is much smaller than the one he prescribes, i.e., just $^1/_6$ D (9%) instead of $^3/_4$ D (33%). From a design point of view, it would have been easier to arrange the columns according to the 10-RF grid: with a consistent intercolumniation of $1^2/_3$ D, the width of the front portico would have been $53^3/_4$ RF. Instead, the columns were spread out more widely over $57^1/_2$ RF, which is one full column diameter more, making the extended façade appear more monumental and filling more fully the 60-RF square contour.

The temple is relatively short, with a podium length (without the stairs but based on the 10-RF grid) of only 1.5 times its width (fig. 4), whereas Vitruvius (3.4.3) recommends a length of twice the width. Given its poor state of preservation, two different side elevations have been proposed: one with 9 columns and an intercolumniation of $1^5/_6$ D or 11 *(M)*, the other with 10 columns and an intercolumniation close to $1^1/_2$ D or 9 *(M)*, the one applied here.[18] Either one would have been possible following the above analysis.

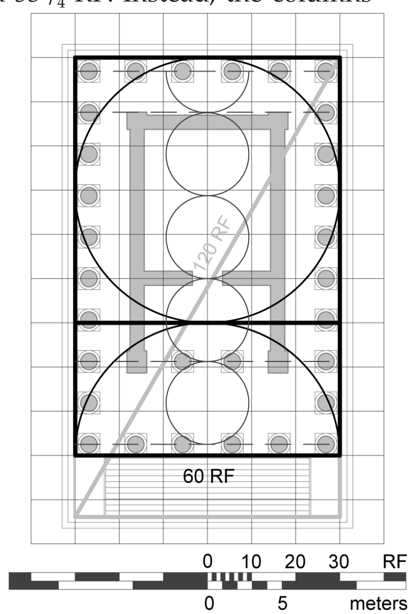

Fig. 4. Geometric resolution of the plan of the Temple of Trajan at Pergamon (author).

Altogether, we find evidence that:

1) The Temple of Trajan was designed relative to a square bi-directional grid with 10-RF modules;
2) The façade's composition was intended to be enclosed

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17 *Coronaeque supra aequaliter imis praeter simas sunt conlocandae*.

18 Nine columns: Stiller (supra n.13) Table XXXI; 10 columns: Nohlen (supra n.11) 159-60.

within a square contour;
3) The primary grid was the basis for a 3-tiered system of modularity, with modules of 10, $6^1/_4$ and $^5/_8$ RF.

Dimensions and proportions of the major elements were probably established first. They were then subdivided into equal segments to establish mutual proportions between components, which were subdivided again to dealing with smaller-scale objects. The evidence for this direction of the process lies in the mathematics: large dimensions are expressed by simple numbers but become more complex as they become subdivided. If the process would have started with small modular dimensions, we would expect them to be represented by whole values.

TABLE 3
MODULAR DIMENSIONS OF THE TEMPLES BASED ON THE 8-RF GRID
(all dimensions in RF)

Temple	*Front no. of columns*	*Width*	*Vert. align. podium grid*	*Podium length*	*Podium length with front walls and steps*
Maison Carrée, Nîmes	6	48	Walls	90 (11¼ x 8)	104 (13 x 8)
Augustus and Livia, Vienne	6	48	Walls	68 (8½ x 8)	80 (10 x 8)
Temple A in forum, *Sufetula*	4	32	Walls	60 (7½ x 8)	80 (10 x 8)
Diana, Évora	6	48	Walls	Unknown	80 (10 x 8)
Temple D in forum, *Grumentum*	6	48	Plinth	80 (10 x 8)	Unknown
Hercules, Ostia	6	48	Walls	96 (12 x 8)	*c.*104 (13 x 8)

The Maison Carrée at Nîmes and the Temple of Augustus and Livia at Vienne

The designs of a second group of temples was based on an 8-RF grid, the widths of their podia being calculated by multiplying the number of façade columns by 8 — i.e., 32 RF for tetrastyle and 48 RF for hexastyle temples (Table 3 and fig. 5). The states of preservation of the Maison Carrée at Nîmes and the Temple of Augustus and Livia in Vienne allow for a comprehensive geometric analysis. Both are hexastyle and they have identical widths (between the podium walls), but the former is pseudoperipteral with a podium of *c.*48 x 90 RF (without the walls flanking the stairs) while the latter is a *peripteros sine postico* with a podium of *c.*48 x 68 RF (also without the flanking walls). A geometric analysis illustrates

TABLE 4

MAISON CARRÉE, NÎMES	AUGUSTUS AND LIVIA, VIENNE
Podium-width: 48 RF Height of cornice line: 48 RF Square contour: 48 x 48 RF, based on the 8-RF module	Podium-width: 48 RF Height of cornice line: 50 RF Square contour: 50 x 50 RF, probably based on the extents of the plinth (50 RF) rather than the walls (see below)
Contour was divided vertically into 7 equal parts of $6^6/_7$ RF each = *H(e)*	Contour was divided vertically into 7½ equal parts of 6⅔ RF each = *H(e)*
Podium: 1½ *H(e)* Colonnade with stylobate: 4½ *H(e)* Entablature: 1 *H(e)*	Podium: 1½ *H(e)* Colonnade: 5 *H(e)* (there is no stylobate) Entablature: 1 *H(e)*
Height of the entablature *H(e)* was divided into 16 *(M)* of $^3/_7$ RF	Height of the entablature *H(e)* was divided into 20 *(M)* of ⅓ RF
Colonnade height (with stylobate): 72 *(M)*	Colonnade height: 100 *(M)*
Column lower diameter: 7 *(M)* = 3 RF	Column lower diameter: 10 *(M)* = 3⅓ RF

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their similarities and differences (Table 4 and fig. 6 overleaf).

The module *(M)* of $^{1}/_{3}$ RF (4 *unciae*) at Vienne was simple and manageable; at Nîmes, however, its value of $^{3}/_{7}$ RF = $5^{1}/_{7}$ *unciae* cannot be expressed in whole units or simple fractions. The analysis of the structure's dimensions confirms that, despite this complexity, it was consistently used in vertical measurements, but also that perhaps a module of $^{1}/_{2}$ RF (or $^{1}/_{4}$ RF) was used for the horizontal alignment of the colonnade. Interestingly, the columns' lower diameter can be expressed as a whole number in both modules: 3 RF = 6 x $^{1}/_{2}$ RF and 7 x $^{3}/_{7}$ RF. In both temples, the layout of the colonnade can also be expressed relative to a modular dimension:

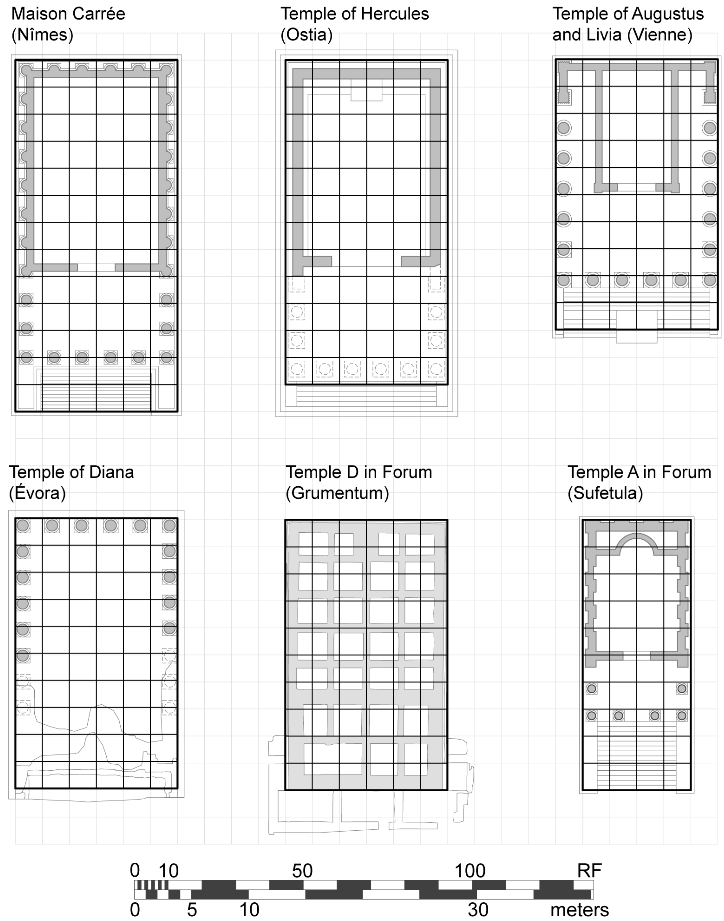

Fig. 5. Selected examples of temples based on an 8-RF geometric grid (author).

TABLE 5

MAISON CARRÉE, NÎMES	AUGUSTUS AND LIVIA, VIENNE
Front elevation: Central interaxial: 8½ RF or 17 *(M)* Side interaxial: 8¼ RF or 16½ *(M)*	Front elevation: Interaxial (center and sides): 8⅔ RF or 26 *(M)*
Side elevation: Interaxial: between 8¼ RF or 16½ *(M)* and 8¾ RF or 17½ *(M)*	Side elevation: Interaxial (average): 9 RF or 27 *(M)*

Similarly to the Traianeum, the façades of both temples were spread over the entire width of the podium better to fill visually the contour of the square. Although the geometric framework of the plan at Vienne is the same as at Nîmes, the structure was made to appear taller and more impressive by supplanting the theoretical constraints of the 8-RF grid. Instead of 48 RF between the walls of the podium, the plinths of the podium were employed for the square contour, making its width and height to the cornice line 50 RF. Consequently, the front colonnade, at $46^{2}/_{3}$ RF, was widened more than at Nîmes ($44^{1}/_{2}$ RF). They would have been $43^{1}/_{3}$[19] and 43 RF, respectively, if the columns were placed at the

19 This would have been similar to the Temple of Trajan, where the theoretical, grid-based width of the colonnade was increased by 1 column diameter.

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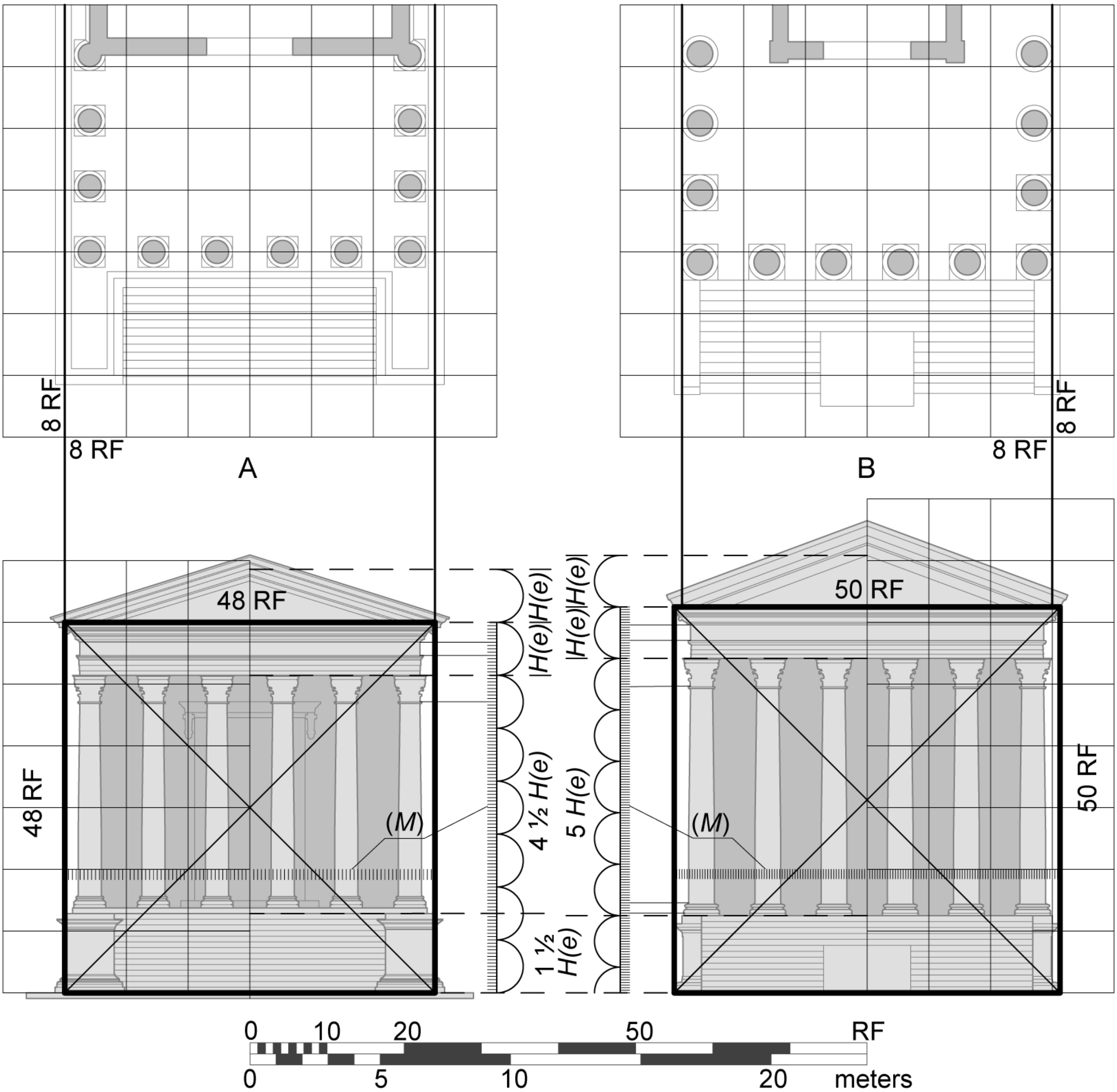

Fig. 6. Comparative study of the composition of the front elevations of (A) the Maison Carrée and (B) the Temple of Augustus and Livia (author).

centers of the 8-RF modules. Figure 6 demonstrates how each architect treated the height of the pediment and the *tympanum* differently. At Vienne, the *H(e)* only included the *tympanum* (as at Pergamon), creating a roof incline of 1 : $2^2/_3$, probably also designed to make the temple look larger. At Nîmes, the *tympanum* and *corona* were included in the *H(e)* but not the *sima* (for a roof incline of 1 : $3^1/_3$), just as in the Temple of Portunus.

Temple of Portunus at Rome

Tetrastyle temples illustrate a different procedure in the design of the façade, seen at the pseudoperipteral Temple of Portunus. While its overall form is well preserved, architectural details have eroded significantly, making it difficult to determine their original dimensions. The layout is based on a 10-RF grid, with the width of the podium between

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the furthest extents of the base plinth measuring exactly 40 RF.[20] Its length — without the front steps but with the bases on both ends — is reconstructed as *c*.$69^{7}/_{10}$ RF, which is only 9 cm ($^{3}/_{10}$ RF) below the modular 70 RF.[21] The temple has an "almost perfect"[22] layout of columns and half-columns, which are exactly 10 RF apart on the sides and, on average, $10^{1}/_{3}$ RF at the front and back (fig. 7). The overall dimensions of its façade are 40 x $51^{3}/_{4}$ RF. A tetrastyle temple was too tall for a square contour to be applied in the same way as in hexastyle temples, which were innately wider: it had to be adjusted to match the breadth of a 4-column façade. The width of the frieze (*c*.34 RF) is identical to the height of the front columns with entablature, a relationship already noted by Wilson Jones, who labels this design as an example of an "adjustment" to the otherwise-perfect Vitruvian plan of the colonnade. According to him, an increase of the interaxial distances in the façade from the grid-based 10 to $10^{3}/_{10}$ RF was necessary to form a square outline in the façade composition.[23] I argue that this was not an "adjustment" but a standard feature of a design methodology.

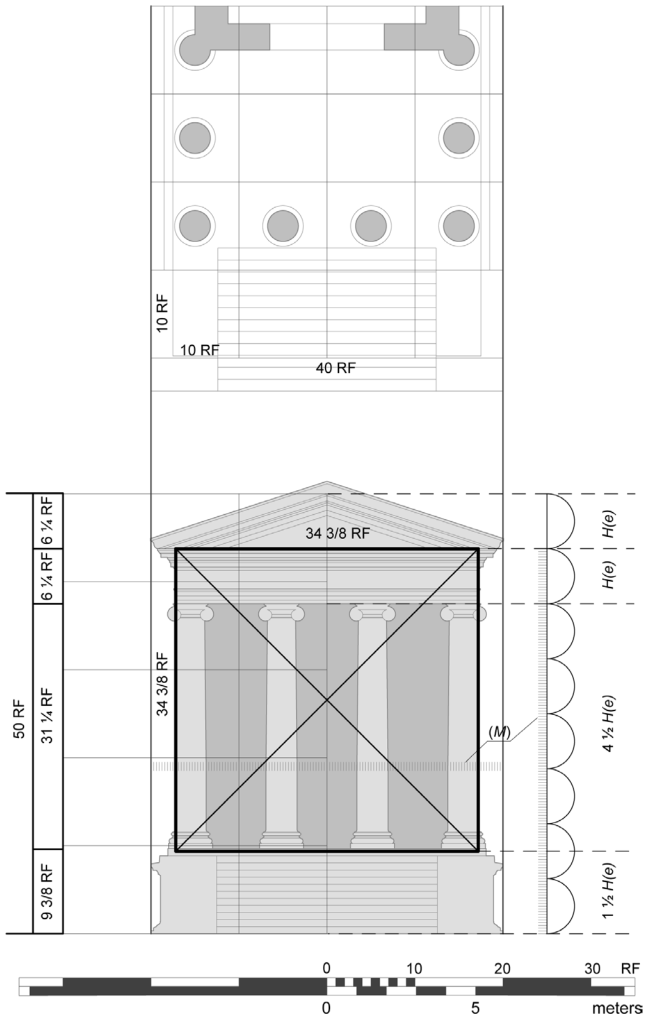

Fig. 7. Study of the composition of the façade of the Temple of Portunus (author).

The geometric analysis shows that the façade follows the same scheme as the previous 3 examples, although with slight modifications:

- The *H(e)* is $6^{1}/_{4}$ RF.
- The alignment of the square contour comprised only the entablature of 1 *H(e)* and the colonnade (with stylobate) of $4^{1}/_{2}$ *H(e)*.
- The height of the podium was $1^{1}/_{2}$ *H(e)* and was not included in the square contour.
- The height of the *tympanum* to the top of the *corona* and without the *sima* was 1 *H(e)*.

Wilson Jones assumed a column diameter of $3^{1}/_{2}$ RF with frontal interaxial distances of $10^{1}/_{3}$ RF to form a perfectly square contour. However, it is possible to argue for a diameter

20 All measurements are taken from J.-P. Adam, *Le temple de Portunus au Forum Boarium* (CollÉFR 199, 1994) 5-109.

21 Considering that the W length of the podium is 13 cm longer than its E one, the error is not significant.

22 Wilson Jones (supra n.1) 65.

23 Ibid. 65-68.

of $3^1/_8$ RF for two reasons: 1) none of the (badly eroded) extant columns or semi-columns exceed this dimension;[24] and 2) their H : D ratio would thus have been exactly 9 : 1, common for the Ionic order, instead of Wilson Jones' *c*.8 : 1. The interaxials of the front portico would change to $10^5/_{12}$ RF (10 *pedes* and 5 *unciae* being easier to use) and the intercolumniations would have been $2^1/_3$ D as opposed to a little less than 2 D or $6^4/_5$ RF. A $3^1/_8$ RF diameter matches better Adam's measured drawings, and the principal square contour still remains. However, due to the erosion, it remains impossible to be certain which, if any, of the two schemes was intended by the architect.[25]

The design process of Roman temples

Based on these analyses, a hypothetical design process can be reconstructed (fig. 8). Following choices such as the prominence of the deity, site choice and budget, the first decision was probably the modular width relative to the number of columns in the façade. The form of the temple — peripteral, *peripteros sine postico* or pseudo-peripteral — was perhaps decided at the same time but it would not have had any impact on the choice of module or façade design. The length of the temple, though important for the project overall, was also of less importance. The pre-eminence of the design of the front elevation in the planning process was in accord with the character of religious practices in the Roman tradition, accentuated by the location of an altar in front of the steps to the podium or set directly on top of them. It was also a practical response to the dense urban context, since the façade and entry portico were visually more prominent than any other element and the podium had to be at an appropriate elevation above the streets for religious ceremonies.[26]

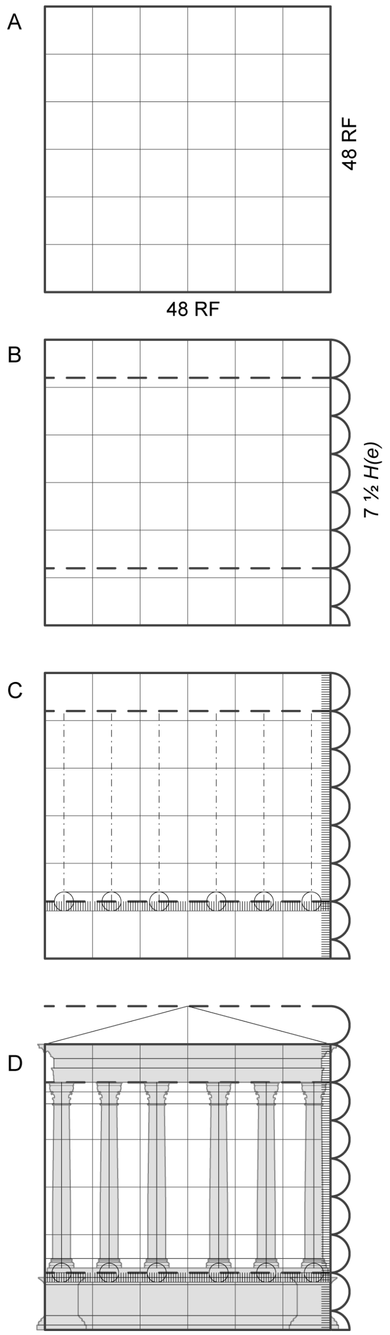

Fig. 8. Hypothetical reconstruction of the basic steps of the design process of the façade of a hexastyle temple based on the 8-RF grid: (A) Drawing of a 48 x 48 RF grid, whose outline was to become the square contour of the front elevation. (B) Dividing the square outline of the front elevation into a selected number of vertical segments *H(e)* (in this case $7^1/_2$). (C) Calculating the location and size of the columns based on the module *(M)*. (D) Dividing larger elements into smaller parts based on the module *(M)* (author).

24 Adam (supra n.20) 89 even refrained from stating a definite size, given their poor state of preservation.

25 Although a few of Adam's measurements do not match exactly their theoretical equivalents relative to $H(e) = 6^1/_4$ RF, they are within the range of tolerances observed in Roman construction: Wilson Jones (supra n.1) 71-72. Adam himself (ibid. 88, fig. 69) also noticed substantially different measurements in details that should have been identical (e.g., the profiles of bases).

26 W. L. MacDonald, *The architecture of the Roman Empire*, vol. II. *An urban appraisal* (New Haven, CT 1986) 133-42.

Next, the proportional system of the front elevation — the *ichnographia* — had to be calculated to establish the alignment of the principal square contour. Its width was found to be aligned with one of three references: the extents of the base-plinths, the walls of the podium or the outline of the corner columns. In the former two, the portico columns were placed as close as possible to the podium edges to create a visual impression of a uniform square contour; in the latter, the columns formed part of the contour, given that their 'edges' aligned vertically with the edges of the architrave and frieze, as noted by Vitruvius (3.5.9), even if technically a round column does not create an edge. Arguments for the horizontal extents of the contour were also diverse. To delineate the upper edge, most commonly the cornice line was used; alternatively, the top of the pediment could be used.[27] The lower horizontal edge of the square contour was found aligned to either the ground level or the floor of the podium (typically without the stylobate). For the temples discussed here, the pediment was part of the same proportional "system of symmetry": the height of the *tympanum* (sometimes with *corona*) was always 1 *H(e)*, and the *sima* (and sometimes the *corona*) was added above.

TABLE 6
PROPORTIONS OF THE PRINCIPAL PARTS OF THE FAÇADES
(ENTABLATURE, COLONNADE AND PODIUM)

Temple	*Number of H(e)*	*Size of the H(e)*	*Entablature*	*Colonnade*	*Podium*
Portunus	7	$6\frac{1}{4}$ RF	1	$4\frac{1}{2}$	$1\frac{1}{2}$
Augustus and Livia, Vienne	$7\frac{1}{2}$	$6\frac{2}{3}$ RF	1	5	$1\frac{1}{2}$
Maison Carrée, Nîmes	7	$6^6/_7$ RF	1	$4\frac{1}{2}$	$1\frac{1}{2}$
Temple of Trajan, Pergamon	8	$6\frac{1}{4}$ RF	1	$5\frac{1}{2}$	$1\frac{1}{2}$

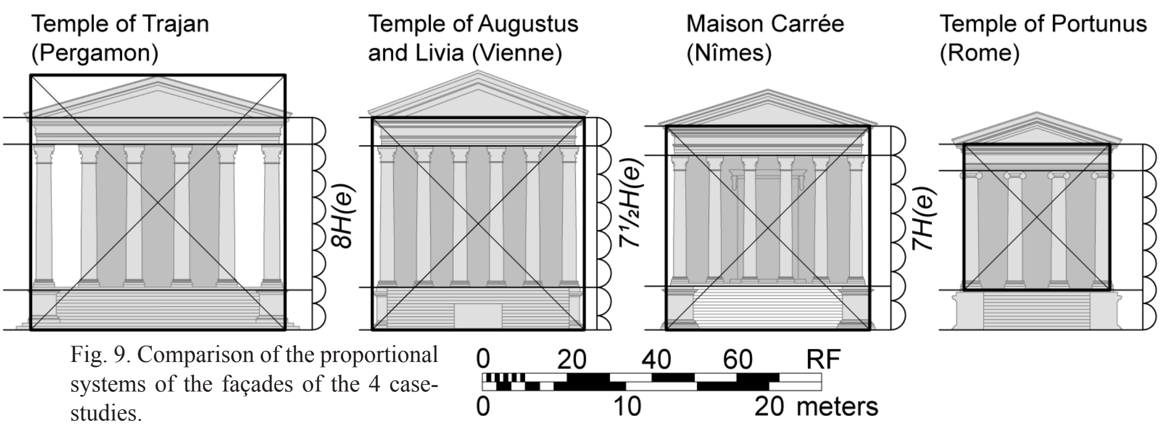

Fig. 9. Comparison of the proportional systems of the façades of the 4 case-studies.

The square contour was divided into equal segments (here between $5^1/_2$ and 8), which would become the large-scale module of the *ichnographia*, the proportional system of the vertical measurements of the façade. Table 6 and fig. 9 show that the number of *H(e)* increases with the size of the structure; the same applies to the ratio of the height of the colonnade to the entablature (always between $4^1/_2$ and $5^1/_2$). However, the entablature was exactly 1 *H(e)* in all of the *c.*30 temples, while the height of the podium was 1 or $1^1/_2$ *H(e)* with only a few exceptions, probably part of an effort to achieve a greater effect in the

27 As in the Temple of Trajan at Pergamon, the Temple of Diana at Mérida and the Temple of Minerva at Assisi.

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dense urban space (Table 9). The main variations in proportions were in the colonnades. Table 6 shows the similarities and differences in the proportional systems: e.g., the vertical proportions of the front elevation of the Temple of Portunus are identical to those of the Maison Carrée ($1 : 4^1/_2 : 1^1/_2$), although the total heights of the entablature (with *corona* and *sima*) were different; and the same *H(e)* ($6^1/_4$ RF) was used in both the Temple of Portunus and the Temple of Trajan, although the overall proportions of the façade to the cornice line were not the same ($1 : 5^1/_2 : 1^1/_2$ versus $1 : 4^1/_2 : 1^1/_2$).

In the next step, the *H(e)* was subdivided into equal segments (usually the largest common denominator, such as $^1/_{10}$, $^1/_{16}$ or $^1/_{20}$), called here the small module *(M)*,[28] to design architectural details. Since it was a common denominator of (e.g.) the column diameters, intercolumniation, height of capitals and bases, and the components of the entablature, it allowed the architect to maintain proportional relationships between them and the larger elements.

The lower diameter of the columns, favored by Vitruvius (3.5.1-15) as the principal module of the design, was obviously also part of the proportional system of every temple. It is roughly (if rarely exactly) half the height of the entablature *H(e)*, but always a multiple of *(M)*. It is impossible to determine which value had the greatest significance for individual architects or in different local design traditions. In all 4 case-studies, the column diameter was a consequence of other dimensions, not the other way round, but the importance attached to it by Vitruvius cannot be ignored and it should be expected that for some temples it was given a higher status.

Although I argue that the 4 case-studies share a consistent geometric methodology of design, there was no single proportional system even for structures based on the same primary grid. It seems that Roman architects developed *symmetria* from the principal modules by dividing them into equal-sized segments, based on the scale of the project and following personal preferences and/or rules learned and developed through practice. Most dimensions can be traced back to this initial proportional system and should not be seen as an on-site improvisations; nor were values rounded up or down, regardless of their numeric complexity. The actual measurements did not seem to matter as much as the precise *ratios* of the proportions. In a sense, the modular system was a set of temporary units, unique to each project, divided or multiplied according to specific needs. We should assume that the variety we observe in the design of temples was stimulated by the continuous pursuit of excellence and design perfection that led to gradual modifications of an archetype. In the same spirit, the design methodology should not be confused with a classical canon of proportions. Based on the variety of mathematical ratios demonstrated here, one can hypothesize that the canons were in fact more temporal and/or localized than previously believed, similar to the variation found in the ornamentation.

The case-studies demonstrate that architects tried to correlate the two systems whenever possible. They took advantage of Roman duodecimal measuring units in which 1 RF = 12 *unciae*, easily dividable by 2, 3, 4 or 6. Not all sets of numbers were sustained equally, however, since the Roman foot was not as amenable to being divided by 5 or 10. The dimensions of the temples based on the 10-RF grid possibly illustrate a solution to this problem, if we accept that architects also used the standard unit of the *palmipes* of $1^1/_4$ RF or 15 *unciae* (a foot and a palm, here abbreviated PP). It provided an important advantage over the RF

28 The $^1/_{20}$ ratio is simply a version of $^1/_{10}$, in which each small module is divided into 2 for greater design flexibility.

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as it could be divided easily both into 2, 3, 4, 6, 8, etc.[29] and into 5 and 10. Table 7 shows how the most important measurements of the temples of Portunus and Trajan are much simpler when expressed in PP than in RF. It also shows how that the numeric values of the total width (48), of the column diameter (3), of the module *(M)* ($^1/_2$) in PP of the Temple of Trajan are identical to those of the Maison Carrée in RF, as well as those of the grid unit (10 RF = 8 PP). It almost looks as if the Temple of Trajan was designed 25% larger than the Maison Carrée simply by substituting PP for RF but maintaining all numerical values, but the dimensions of other parts display different correspondences. Possibly architects and builders switched between standard units and the ratios of local modular units depending on the particular needs of a project or what was more convenient at the moment.

TABLE 7
PRINCIPAL MEASUREMENTS OF THE TEMPLES OF PORTUNUS AND TRAJAN AND THE MAISON CARRÉE
expressed in Roman feet (RF) and palmipedes (PP). Matching numbers are in **bold**

	Portunus		*Trajan, Pergamon*		*Maison Carrée, Nîmes*
	RF	PP	RF	PP	RF
Grid size	10	8	10	**8**	**8**
Width of the temple	40	32	60	**48**	**48**
Principal square contour	34⅜	27½	60	**48**	**48**
Height of the entablature *(H(e))*	6¼	5	6¼	5	$6^6/_7$
Column diameter (D)	3⅛	2½	3¾	**3**	**3**
Column height (H)	28⅛	22½	33¾	27	$30^1/_7$
Intercolumniation axis	$7^7/_{24}$	5⅚	7½	6	**5½**
Intercolumniations sides	$7^7/_{24}$	5⅚	6⅞	**5½**	5¼
Module *(M)*	?	?	⅝	½	½ or $^3/_7$

The almost identical podium heights and entablatures in all case-studies (Table 6 and fig. 9) seem to imply that, no matter the size and form of the temple, these proportions were basically fixed. They were probably based on more pragmatic needs: the podium needed to stand out above the street and the entablature might have been conditioned by the length and height of blocks capable of spanning the distance between the columns without breaking. Their measurements also had to correspond with the overall system of symmetry. Vitruvius (5.6.7) states (relating to theaters) that:

> Now it is not possible to have the proportional system for every theater carried out according to every principle and to every effect. Instead, it is up to the architect to note in which dimensions it will be necessary to pursue symmetry and in which to make adjustments according to the nature of the site or the size of the project. There are things that, because of their function, ought to be made of the same size both in a very small theater and in a large one: things like rows of seats, transverse aisles, podia, passageways, stairs, performing platforms, tribunals, and whatever else might occur where necessity compels departure from symmetry so as not to impede function.

Confronting Vitruvius

Is it possible to reconcile Vitruvius's writings with the above results? The Vitruvian model for Roman temples using the column diameter as the primary module and the best

29 Yielding fractions based on $^1/_2$, $^1/_3$, $^1/_4$ and $^1/_8$, which were easy to calculate both geometrically and mathematically.

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method to achieve perfection cannot be confirmed as a universal principle. In fact, he himself (1.2.4) allowed for other possibilities:

> (…) in temples, this symmetry derives from the diameter of the columns, or from the triglyph, or from the *embates*.[30]

His section on the design of Roman temples can be roughly divided into two general parts. In the first, he offers precise information, such as numerical data, ratios, dimensions and terminology. The second part is a narrative about the overall context, aimed at raising the discipline of architecture to the levels of an intellectual discourse. For modern scholars, the concrete, quantifiable instructions were deemed reliable and became a foundation for the study of Roman architecture, but the narrative part was not analysed in the same way. Research shows, however, that the relevance of both parts should be measured by the archaeological data: one should read the *De architectura* through the archaeological evidence and not study archaeological findings with the book in hand.[31] The disciplined proportional systems based on simple arithmetic ratios — e.g., regarding the intercolumniations (3.3.1-13) — does not align with the countless variations found by researchers of our own time.[32]

If the treatise's numerical information cannot be verified, what about other parts of the text? Especially relevant for this study is the description (3.1) of the proportions of the human body as the source of *symmetria*. In my opinion it appears not by coincidence in the chapter on temples, rather than in the introduction. It describes the circle and square as perfect shapes into which the equally perfect human form can be enclosed. This should perhaps be read as an allusion to the "rule of the square" in the composition of temple façades. The harmony of the body is represented by a square, of which the principal module is the head, which is between $^1/_6$ and $^1/_{10}$ of the overall height (3.1.2), depending whether only the face, the crown to the bottom of the chin, or the crown to the chest line is being measured. These are the same as the proportions between the height of the entablature and the square contours of the case studies (fig. 10). Also similar to what has been found in the present study are the relationship between the "whole" (*universam totius magnitudinis*), its "parts" (*partibus singulis*) and "units" (*singulares*) (3.1.3-9), and the different ratios for subdividing them, as accentuated by paragraphs 5-9.

Vitruvius' goal of symmetry in architectural composition is inherently elusive but it can be accomplished through "perfect" proportions. He discusses several numbers and whether they are more or less than "perfect". Among them are those found in the proportional systems of the temples analyzed in this article. Affirmation of the high quality of projects through numeric ratios instilled a sense of objectivity in design. However, not just *one* ratio was always "perfect" and the ratio could not be expressed by just *any* value: the

30 ... *in aedibus sacris aut e columnarum crassitudinibus aut triglypho aut etiam embate* ... . Elsewhere (4.3.3-4), Vitruvius associates the word *embates* with the radius of a Doric column, as a way to use its dimension in design, like a module: "The façade of a Doric temple should be divided along the stylobate into 27 parts if the building is going to be tetrastyle, if hexastyle, into 42. One of these parts will be the module (*modulus*), which is called *embatêr* (ἐμβάτης) in Greek. Once the module has been decided, all the calculations for the proportions of the whole project may be carried out. The diameter of the columns will equal 2 modules, the height of the columns with their capitals, 14". Rowland and Howe's translation of *embates* in 1.2.4 as the "lower radius of the columns" is therefore, in my opinion, incorrect.

31 Supra n.1.

32 E.g., Wilson Jones (supra n.1), Barresi (supra nn. 4-5).

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symmetry was subject to preferences, qualities and functions of architecture. In our case-studies, the ratio between the heights of the entablature and the colonnade ranged between 1 : 4 and 1 : 7, including halves (i.e., $1 : 4^1/_2$, $1 : 5^1/_2$, etc.). 'Symmetry' clearly was not attached to any particular numbers for every part of classical architecture, but it was defined by them nevertheless because mathematical proportions were an accepted method of relating visual impressions. In this way they could be preserved and recalled, as a set of values.

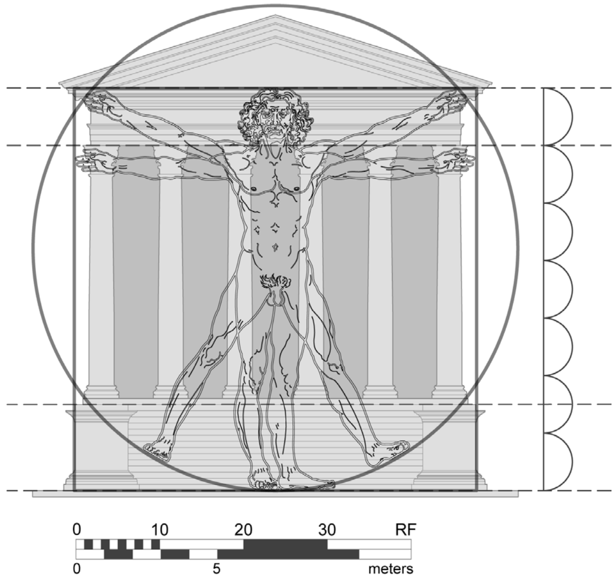

Fig. 10. The 'Vitruvian Man' by Leonardo da Vinci based on Vitruvian basic proportions, superimposed on the façade of the Maison Carrée (author).

The system of proportions expressed by pairs of numbers, similar to those of a rectangle, naturally converges on a square, the ideal rectangle from which all ambiguity has been eliminated. The ratio 1 : 1 is therefore the basis for all other relationships. As demonstrated, not every Roman temple could have had its whole façade enclosed in a square (e.g., the Temple of Trajan), or even its whole lower part (e.g., Nîmes and Vienne). The "rule of the square" was applied differently simply because the façade proportions had to change relative to the size and class of the structures, but it was at the core of all our case-studies and probably represented the starting point for the development of the *ichnographia*. The size of the square arrived at, subsequent to the initial layout grid, was used as a reference for the entire "system of symmetry" of the temples.

But why would Vitruvius not express the rôle of the square in the design more explicitly when he later recited individual ratios of columns, entablature and pediments? In my view, the "rule of the square" was common practice and did not require detailed description. To Vitruvius' contemporaries the parallel between the body and temple design was obvious. Therefore he could dispense with simple references to well-known truths, presenting it instead in a poetic form (3.1.4):

> And so, if Nature has composed the human body so that in its proportions the separate individual elements answer to the total form, then the ancients seem to have had reasons to decide that bringing their creations to full completion likewise required a correspondence between the measure of individual elements and the appearance of the work as a whole. Therefore, when they were handling down proportional sequences for every type of work, they did so especially for the sacred dwellings of the gods, as the successes and failures of those works tend to remain forever.

Instead, he described in detail the specific mathematical ratios that were his own contribution to architectural design (following Hermogenes, at least to some degree).[33] I believe that in this way he made clear that the traditional design rules based on the symmetry of the human body and the geometry of the square that were being used by architects were still valid and the most important ones. They were the key to the *symmetria* in the architecture of temples. More specific mathematical relationships, however, would be needed

33 Rowland and Howe (supra n.1) 14; Wilson Jones (supra n.1) 39.

for the colonnade and the entablature, and those that he prescribed were mathematically whole, ensuring a greater level of perfection of the designs.

Conclusions

Among the first of his long list of skills that an architect should possess (1.1.4) was geometry, since "(…) the difficult issues of symmetry are resolved by geometric principles and methods". An architect should also be versed in theory, since "reasoning (*ratiocinatio*) is what can demonstrate and explain the proportions of completed works skillfully and systematically" (1.1.1). Practice and theory formed a perfect alliance, in which geometry and proportions were fundamental tools. In my opinion, any study of ancient designs that were based on these principles must follow the same pattern. However, Vitruvius' guidelines for temples appear to be of his own invention and not an objective account of the *status quaestionis*. In the absence of other written sources, research into the geometric framework of Roman temples will always be subject to uncertainties about whether new, modern theories (like the present one) represent actual 'objective' design schemes or are just another set of geometric relationships that happen to be present in the design but were not the actual guiding principles. Correlation does not always equal causation.

I believe that my study demonstrates that the architects of these 4 temples used a consistent design methodology in which the principal grid, the "rule of the square" and the subsequent modular units provided an efficient apparatus for the pursuit of *symmetria*. This framework was much more flexible than the set of proportions prescribed by Vitruvius. The design process was not a mechanical application of standard geometric ratios and principles but a true design effort in which the architect had the opportunity to demonstrate his skill and creativity. I hope to have demonstrated the potential for allowing individual expression in the classical forms. The proposed scheme resonates well with the richness of proportions and geometric relationships found in the buildings as preserved. The same design methodology could result in different sets of proportions between the diameter of the columns, their height, and the dimensions of other architectural details. The guidelines prescribed by Vitruvius for the design of temples can be viewed as one possible "system of symmetry", but not the only one used or even the most common one.

The above analysis also raises questions needing to be addressed through further studies:

- What were the geographic and temporal extents of the proposed design methods? They have been confirmed here for 34 cases, but undoubtedly not all Roman temples complied. Further temples should be analyzed to arrive at more comprehensive conclusions.
- What were the origins of the grid-based layout and the "rule of the square"? Since the two principal inspirations for the archetype of the Roman temple emerged from architectural traditions of Etruria and Greece, those should be examined for possible influence on the design processes.[34]

Despite the limited scope of this study, the preserved physical evidence of a geometric framework of these temples appears to sustain the proposed design methodology, which I offer to the scholarly community for comment.

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34 Barresi's studies (supra nn. 4-5) would indicate the significant impact of Etruria, while Vitruvius's own account points towards Greece.

TABLE 8
MODULAR DIMENSIONS OF TEMPLES WITH SUFFICIENT EVIDENCE FOR PODIUM RECONSTRUCTIONS

Temple	*Front no. of columns*	*Grid size (RF)*	*Podium width (RF)*	*Podium length (RF)*	*Vert. align. podium grid*
Quattro Tempietti, Ostia	4	6	24	40	Walls
Republican 2, Ostia	4	6	24	42	Walls
Temple in forum of *Baelo Claudia*	4	7	28	70 with front	Central temple: plinth Two side temples: walls
Temple in Piazzale delle Corporazioni, Ostia	4	10	40	80 with front	Walls
Temple A on acropolis of Volterra	4	10	40	80 with front	Walls
Apollo, Pompeii	6	6	36	78 with front	Plinth
Spes, Rome	6	6	36	78 with front	Walls?
Hercules, Ostia	6	8	48	96	Walls
Janus, Rome	6	8	48	72	Walls?
Temple D in forum of *Grumentum*	6	8	48	80	Plinth
Juturna (Largo Argentina A), Rome	6	9	54	90 with front	Plinth
Juno Sospita, Rome	6	9	54	117 with front	Walls
Feronia (Largo Argentina C), Rome	6	10	60	80	Walls
Divus Iulius, Rome	6	10	60	80	Plinth
Juno, *Gabii*	6	10	60	80	Plinth
Jupiter, Ostia	6	10	60	120 with front	Plinth
Apollo Palatinus, Rome	6	14?	84	154 with front	Plinth

* with front = with front walls and steps

TABLE 9
MODULAR DIMENSIONS OF TEMPLES WITH SUFFICIENT EVIDENCE FOR ELEVATION RECONSTRUCTIONS

Temple	*Front no. of cols*	*Grid size (RF)*	*Podium width (RF)*	*Podium length (RF)*	*Vert. align. podium grid*	*Vert. align. square grid*	*Horiz. square contour align.: upper/lower*	*H(e) size*	*H(e) no. to cornice*	*Ratio Entablature: Columns : Podium*
Augustus, Pola	4	7	28	70 with front	Walls	Columns	Column / Podium	5	7½	1 : 5½ : 1
Temple A in forum of *Sufetula*	4	8	32	80 with front	Walls	Walls	Podium / Cornice	6⅖	6½	1 : 4 : 1½

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Temple	*Front no. of cols*	*Grid size (RF)*	*Podium width (RF)*	*Podium length (RF)*	*Vert. align. podium grid*	*Vert. align. square grid*	*Horiz. square contour align.: upper/lower*	*H(e) size*	*H(e) no. to cornice*	*Ratio Entablature: Columns : Podium*
Portunus, Rome	4	10	40	80 with front	Plinth	Columns	Cornice/Podium	6¼	7	1 : 4½ : 1½
Mihr, Garni[1]	6	7	42	63	Plinth	Columns	Pediment/Podium	4⅔	8	1 : 5 : 2
Maison Carrée, Nîmes	6	8	48	104 with front	Walls	Walls	Cornice/Ground	$6^{6}/_{7}$	7	1 : 4½ : 1½
Augustus and Livia, Vienne	6	8	48	80 with front	Walls	Plinth	Cornice/Ground	6⅔	7½	1 : 5 : 1½
Diana, Évora	6	8	48	80 with front	Walls	Plinth	Pediment[4]/Ground	6⅔[4]	6½[4]	1 : 4 : 1½[4]
Diana, Mérida	6	10	60	100	Walls	Walls	Pediment[4]/Ground	5⅓[4]	9[4]	1 : 6 : 2[4]
Trajan, Pergamon	6	10	60	90	Walls	Walls	Pediment/Ground	6¼	8	1 : 5½ : 1½
Minerva, Assisi	6	10	60	?	Walls	Walls	Pediment/Ground	6⅔	7½	1 : 5½ : 1
Vespasian, Rome	6	12	72	108? with front	Plinth	Plinth[4]	Cornice/Lower pod.[6]	10⅔[4]	6½[4]	1 : 4½ : 1[4]
Antoninus and Faustina, Rome	6	12	72	144?	Walls	Walls[4]	Cornice/Ground	10½[4]	7[4]	1 : 4½ : 1½[4]
Apollo Sosianus, Rome	6	12	72	144?	Walls	Walls[4]	Cornice/Lower pod.[6]	11⅖[4]	7[4]	1 : 4½ : 1½[4]
Saturn, Rome[2]	6	12	72	120?	Plinth	Plinth[4]	Pediment/Lower pod.[6]	6⅓[4]	9½[4]	1 : 6½ : 2[4]
Venus Genetrix, Rome[2]	8	10	80	110[3]	Plinth	Plinth[6]	Cornice/Lower pod.[6]	$9^{3}/_{8}$[4]	6½[4]	1 : 4½ : 1[4]
Castor and Pollux, Rome	8	12½	100	162¼ with front	Walls	Walls	Pediment[4]/Ground[4]	11¼[4]	7½[4]	1 : 4½ : 2[4]
Mars Ultor, Rome	8	15	120	165[3]	Plinth	Columns[5]	Cornice/Podium	12½[4]	7[4]	1 : 5 : 1[4]

* with front = with front walls and steps
(1) This structure was significantly reconstructed/re-assembled in modern times.
(2) Reconstructions in antiquity might have changed the original geometric framework (and its clarity to us today).
(3) Length of the rectangular podium, not including the apse.
(4) Estimated values based on incomplete data or reconstructions.
(5) Due to the exceptional size of the Temple of Mars Ultor, and to highlight that size even more, the square contour aligns horizontally with the ground floor and the top of the pediment, and vertically with the axes of the corner columns.
(6) The structure has a 2-tiered podium; the square contour was measured from the top of the lower podium (Lower pod.).

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