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The Treatise on Fortification by Guarino Guarini

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Abstract Renowned for Baroque architectural masterpieces such as the Chapel of the Holy Shroud and the Church of San Lorenzo, both in Torino, Guarino Guarini (1624–1683) also composed a treatise on fortification, published in 1676. At the time Guarini was part of the Savoy Court and was tutor to Prince Ludovico Giulio di Carignano, a relative of the Duke of Savoy. After a brief presentation of the events in Guarini's life leading up to his residency in the Savoy city of Turin, and a description of the science of military architecture in his day, this present paper discusses Guarini's treatise and compares it to the work of his contemporaries, Claude-François Milliet Dechales (1621–1678) and Nicolas-François Blondel (1618–1686).

Keywords Military architecture · Fortification · Guarino Guarini · Geometry · Arithmetic · Trigonometry · Baroque architecture · Claude-François Milliet Dechales · Nicolas-François Blondel

Introduction

Guarino Guarini of Modena, Italy, was born in 1624, became a priest and elite scholar in the Order of Clerks Regular, forerunners of the Jesuit order, and after an active life, died in Milan in 1683.[1] He is now regarded as one of the greatest Italian architects of the High Baroque (Meek 1988; Millon 1982), although he was also engaged in mathematics, philosophy, astronomy and as we shall see, teaching. His order was dubbed the Theatines after one of its founders, the Bishop of Teatro, who

[1] For more about the life and work of Guarini, see (Manconi 2003).

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resigned his chair, and it shared similar intentions in education and missionary work with the Jesuits in terms of Counter-Reformation action against the Reformers.[2] In his busy life in Italy, France and other countries (about which, however, we know very little), Guarini was adept enough to concern himself with military architecture, at least in terms of teaching it to a student. This student was the Prince Ludovico Giulio of Carignano, a distant relative of the Duke of Savoy and Prince of Piedmont, Carlo Emanuele II (1634–1675).

The Duke called Guarini to Torino to complete his dynastic Chapel of the Holy Shroud, a possession of his family, partly in the Royal Palace but accessible from the Cathedral of St. John. The Theatine left Paris on this mission in 1666, receiving his patent of duty in December of that year, which engaged him for the rest of his life. It appears that this career move was important for Guarini, as he left a way of life in Northern Europe for the courtly life of Torino.

Guarini in Paris

Guarino was quite active in the French capital, as he was building a Parisian church, Sainte-Anne-la-Royale, for his order, funded by the French first minister, Jules Cardinal Mazarin, which the Theatine left uncompleted.[3] He was working on a *cursus philosophici*, called the *Placita philosophica physicis rationibus experientiis*, *matemathicisque ostensa* (Guarini 1665); this encyclopaedia is marked by a treatment of light, uncommon in such a production, a discussion of Galileo's statics of the beam, an overview of medicine, the idea of habit in Aristotle, and support for Ptolemaic cosmology, though mentioning the systems of Copernicus and Tycho Brahe. He was also involved in preparing an encyclopaedia of mathematics, the *Euclides audactus* (Guarini 1671), so that his Theatine novices could study this important subject. There is a distinct possibility that he was teaching at the Sorbonne, as he was highly educated in both theology and philosophy. We are ignorant of his exact movements in France, and whether he may have travelled much to Flanders and other places. However, when he came to Torino and was asked to teach mathematics to a member of the ducal family, he published this work as a treatise of fortification (Guarini 1676), claiming to know the usage of military architecture in France and Flanders, as well as Italy.

Guarini's stay in Paris from 1661 to 1666 was important, as he became aware to a great extent of the claims of the Cartesian school of mathematics and physics. While he did not adopt algebraic notation, which was then on the rise, the Theatine was well informed about Descartes and criticised his school of thinking in the mathematics of the *Euclides adauctus*.

[2] Sometimes such intentions were generalised to the succinct aim of the reform of the clergy, with more intensive programmes of seminar education available, leading to greater observation of rules and more active missionary service.

[3] Guarini did not complete it due to failure of funding, and its remains were later destroyed in 1823.

So what was Guarini's attitude to the French scholar's new mathematics? Guarini, in the *Euclides adauctus* issued a warning about the probable rationality of middle mathematics, to the extent of not dealing with them in this work:

> Mathesis is not evident according to its parts: For it is deficient from [its] institution in its many parts by defect of principles, & takes pleasure in probabilities: Thus Astrology, Optics, and Spherics, & the Theories of the Planets, & many other parts of which it is evident,… that mathematical Physics are probable. For who can believe that a line can be cut in two perfectly? A perfect circle can be drawn?… Because in the matter of Mathematical problems, as we have warned, that abstract must always be understood, as the conclusions clearly show (Guarini 1671: 26, quoted and translated in McQuillan 1991: 164).

In my doctoral thesis (McQuillan 1991), I stated that Guarini's arrival in the Paris of the 1660s was subject to two possible and linked interpretations. One was a genuine denunciation of the seventeenth century's increasing involvement with the mathematisation of nature, a task that was denied in traditional philosophy, even in the face of Pythagorean and Platonic encouragement. Classical and Scholastic philosophy held that physical causation was best accounted for only in dialectic and not mathematically, in which no causation could be divined. The second attitude that Guarini adopted was a rejection of the *méchanisme* of the Cartesian school,[4] after Descartes and others were added to the Roman Index of Prohibited Books, as well as the current tribulations of the French Jansenists, easily seen as a revolt against religious orthodoxy and not far from the rationalists among the Cartesian school (McQuillan 1991: p. 165ff.). Guarini was above all orthodox, and stood on time-honoured principles that the Church espoused with maximum authority.

Seventeenth-Century Fortifications

Guarini's residence in Paris overlapped that of the greatest military architect of the day, namely Sébastian le Prestre de Vauban (1633–1709). This prominent soldier and Marshal of France was remarkable in using his gifts to quickly analyse a terrain and erect permanent fortification and field defences against an enemy. The deployment of gunpowder fortifications was an Italian invention, subsequent to the French attack on Italy in the late fifteenth century, and its development was aided in no small measure by such an artistic personality as Michelangelo. The principles of military architecture are clear; low-lying polygonal walls (either regular, for new cities, etc., or irregular, for well-established sites) with projecting bastions at the angles, beyond which there is an inner series of a linked ditch surrounded by a ravelin or inclined bulwark, and outer series of lighter defences such as defended gun-placements, half-moons and such light earthworks, with trenched links to the main fortification. Such means provided attacks by the defenders on any enemy, and

[4] There may have been an implicit disagreement with Galileo's mathematical physics, but his name was not mentioned in the *Euclides adauctus*.

sometimes trees were grown on top of the main walls or ramparts, to provide fuel in case of siege. Provision for immediate access to the outworks by stairs and trenches allowed flexibility, and there were no concealed external parts, as guns were able to be deployed in all directions, e.g. parallel to the curtain walls between bastions. All sorts of further strategies and devices were used, such as flooding in the Low Countries, outworks as mentioned, and the use of saps and mines to subvert either defender or attacker (Fig. 1).

Vauban's superior skills in either offensive or defensive military architecture, and his particular speciality in siegecraft in Flanders was the cue for surrounding the fortress with parallel lines of entrenchments calculated mathematically in terms of the range from which the enemy could be bombed with mortar bombs, and subsequent entrenchments, sapping and mortaring were worked out in detail according to a timetable. This allowed his patron, King Louis XIV, to bring his ladies to witness the last stage of a siege, when the final assault was accompanied by violins in obedience to the same timetable (Ashley 1946: 90).

A rival aspect of fortification was the sixteenth-century application of the *tenaille* (from Latin: tentacle). This was a low-lying structure contained usually by parallel walls, with one or two re-entrant angles, placed beyond the curtain wall between two bastions. This development went hand-in-hand with Baroque stylistics, but could only be fully appreciated in a map or diagram of the plan. Such an addition enhanced the stellated figure of the overall configuration of fortification, and its fundamental purpose was to extend the influence of artillery and musketry on the attackers. Another aspect was the rival layout of the *cremaillère*, or indented trace, arising from a staggered trace. However, by the beginning of the seventeenth century, the bastioned trace had become most popular, where flanks faced each other slightly, and were connected by a curtain.

> For those who objected to casemate fire, the bastioned trace was the way to salvation. They were soon in a majority; perhaps because the symmetry and completeness of the layout captivated the imagination. At all events the bastioned trace… held the field in one form or another practically without a rival until near the end of the 18th century. The Italian engineers, who were supreme throughout most of the 16th century, started it; the French… developed it, and officially never deserted it until late in the 19th century, when the increasing power of artillery made encientes of secondary importance (Jackson 1910: 686).

All layouts discussed here are of the bastioned trace model.

The Island of Malta, ruled by the Sovereign Military Hospitaller Order of St John,[5] employed Italian building experts to defend the port of Valetta, site of the greatest maritime defences, and at this time, a young French knight, Mederico Blondel (1628–1698), had been sufficiently educated in mathematics to undertake such tasks himself for his Order. Mederico lived mostly on Malta, designed some churches and laid out the Cottonera Lines. He was the younger brother of Nicolas-

[5] The Grand Master of the Order was the Pope. He is still the master of this order, now devoted to medicine.

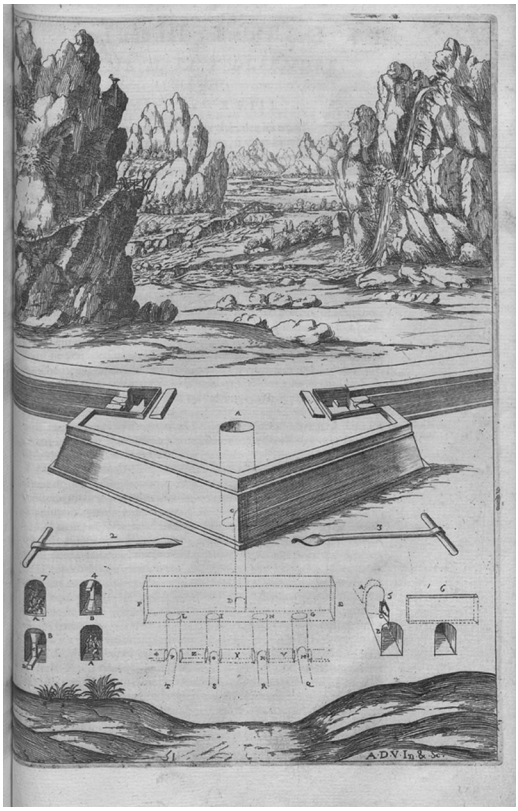

Fig. 1 Antoine de Ville, figure showing the digging of tunnels and saps. *Image*: (De Ville 1640: Pl. 51)

François Blondel (1618–1686), soldier, mathematician, architect, author and first Director of the Académie royale d'architecture, Paris. So there was a lively awareness of the role played by mathematics in the experience and technology of constructing fortifications, advanced by the Blondel brothers in the progress of fortifications in the seventeenth century, and in overall terms by contemporary French military engineers. While today, commentators are appreciative of the power of Guarini to invent versions of capitals and such details (Scott 1995), Blondel was involved in creating 'drawing machines' to carve the full-scale entasis on the shafts of columns, as he explained in one of his architectural works (Blondel 1676).

The Principality of Piedmont was conquered by the Counts (later the Dukes) of Savoy in the fifteenth century, and Torino, its new capital, was slowly attracting artistic personalities as the Renaissance advanced. Palladio paid a brief visit, and a corps of native Savoyard architects was educated to allow this Court, between Italy and France, to improve its status as an able government and military entity. Part of foreign policy was to marry the ducal heir to a daughter of the French crown to avoid conquest from the west, and the Court was bilingual.

For all these reasons, we can appreciate that in the education of a prince, training in military architecture was important, not least as an introduction to mathematics,

and many teachers supplied this need, sometimes with extravagant and useless exaggeration, as we shall see. Given such an important context in terms of education and power, it is not surprising that Guarini took an interest in such affairs, and many have already remarked on his acceptance of French Gothic architecture, beyond the usual contempt of Renaissance architects of the time. In his greatest work, the Chapel of the Holy Shroud, the high windows in its drum attest his awareness of Gothic achievement. Whatever Guarini knew about such matters before his visit to France, it is important to realise that he gained much from his stay in Paris. The most obvious example of the kind of thing he learned is the ironwork lacing the brick arches in the dome of the Chapel of the Shroud, as large stones were hard to acquire in Paris, and this was the structural response in that city. We are also warned about the development of useless programmes of fortification, and therefore we are prepared to examine Guarini's text on this subject with due attention. This was a serious flaw in some tracts on the subject, as Lt.-Col. Louis Charles Jackson, of the Royal Engineers, warns us, referring to the so-called 'systems' of Vauban and others:

> Many of the "systems" published at this time [sixteenth-eighteenth centuries] were elaborated by men who had no practical knowledge of the subject, some of them priests who were engaged in educating the sons of the upper classes, and who had to teach the elements of fortification among other things. They naturally wrote treatises, which were valuable for their clearness of style; and with the industry and ingenuity the elaboration of existing methods was a very congenial task. Most of these essays took the form of multiplication and elaboration of outworks on an impossible scale, and the culmination in such extravagances as the system of Rhana, published in 1769 (Fig. 2). These proposals, however, were of no practical importance (Jackson 1910: 688).

With respect to Vauban, he did not believe in systems of fortification, as he repeatedly declared: 'One does not fortify by systems but by common sense' (quoted in Jackson 1910, 688).

So this will be a question here in examining Guarini's treatise. He was a priest and a poetical dramatist,[6] educating a pupil of the upper classes: did he indulge in 'such extravagances'? Guarini was a serious person, just like the Jesuit Claude-François Milliet Dechales (1621–1678), a popular geometer and the writer of a mathematical encyclopaedia, *Cursus seu mundus mathematicus* (1674), a three-volume set of tomes on mathematics, natural philosophy, fireworks, and architecture, both military and civil, including a *tractatus* on timber construction. Dechales, a Savoyard from Chambery, was inclusive in treating such a nicety as timber construction, first dealt with by Philibert de l'Orme, and extremely rare to find in such a work at that time. Guarini quoted this *corpus magnus* in his own *Architettura civile*, and knew Dechales, as the Savoyard priest may have passed through Torino en route for Milan; the Theatine visited him in Milan, where he died. Along with Blaise François Pagan (1603–1655) and Antoine de Ville (1596–1656), French experts with publications in fortifications (Pagan 1645; de Ville 1640), Dechales

[6] Guarini wrote *La Pietà trionfante* (Messina 1660), an elaborate political and poetic drama of the times.

Fig. 2 Rhana's 'extravagant' fortifications. *Image*: (Jackson 1910: 688)

was an important point of reference for Guarini's deliberations in military architecture.

Guarini in Torino

The Duke invested Guarini with the patent of ducal engineer to construct the dome to the Chapel of the Shroud in December, 1666. However, outside this formal duty, he was employed by the Duke's sister and the Savoy-born Emanuele Filiberto, Prince of Carignano (1628–1709), the near deaf-and-dumb first cousin of Carlo Emanuele II.[7] For this personality he built the Palazzo Carignano, Torino, 1679–1685, probably the best princely European residence in the second half of the seventeenth century, with close references to the recent works of Bernini and Borromini, and the renovation of the feudal Castle of Racconigi, outside Torino. This Prince was an effective military leader and had a nephew, Ludovico Giulio, Prince of Carignano, Knight of Savoy, who Guarini was asked to instruct in religion and mathematics. This is the reason for the publication of the treatise, *Il Trattato di Fortificatione*, *Che hora si usa in Fiandria*, *Francia and Italia*, *Composto in Ossequio del Sereniss. Prencipe Lodovico Giulio, Cauagliere di Sauoia* (Guarini 1676) (The Treatise on Fortification which is now used in Flanders, France and Italy, composed in honour of the Most Serene Prince Ludovico Giulio, Knight of Savoy) (Fig. 3).

Totalling 132 pages with an addition twelve pages of full-page diagrams, and measuring 18 cm in height, this is a relatively slight work, and certainly explains the attention that Guarini devoted for this educational task to the ducal family. Teaching was an important part of the activities of learned orders in the Church, especially for someone with his intellectual gifts. Guarini had taught in Messina, probably mathematics in Guastallo and then allegedly at the Sorbonne, so it was

[7] When Carlo Emanuele II died in 1675, Emanuele Filiberto was declared *heir presumptive* during the childhood of the legitimate heir. This Prince of Carignano was taught the sciences by Alessandro Tesauro, another courtly expert on mythology and rhetoric.

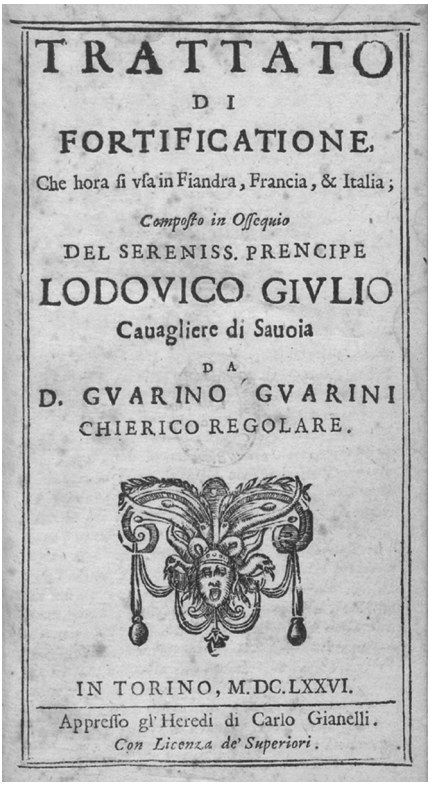
TRATTATO
DI
FORTIFICATIONE,
Che hora ſi vſa in Fiandra, Francia, & Italia;
Compoſto in Oſſequio
DEL SERENISS. PRENCIPE
LODOVICO GIVLIO
Cauagliere di Sauoia
DA
D. GVARINO GVARINI
CHIERICO REGOLARE.
IN TORINO, M.DC.LXXVI.
Appreſſo gl' Heredi di Carlo Gianelli.
Con Licenza de' Superiori.

Fig. 3 Title page of *Trattato di Fortification* (Guarini 1676)

commensurate with his princely employment to engage in this aspect of life. Certainly a glance at the work explains the main purpose of Guarini's task with his young prince, as the basic principles of geometry and arithmetic are presented before arriving at military architecture. This is very typical of Guarini's methodical approach to any subject, as he was a trained philosopher in Second Scholastic as well as in mathematics. Such care is reflected in the restricted number pages of his treatise in fortification.

Guarini built an ornamental gate in the early fortifications of Torino, *Porta del Po*, a gate leading to the bridge over the Po. The bridge itself has long vanished. However, the gate is illustrated in a surviving copper engraving in his *Architettura civile* and exhibited typical touches of Guarini's design influenced by Borromini, with angled blocks on each side of an outwardly-curved centre-piece (Fig. 4).

Three obelisks appear above, the central one raised on blocks, over the arms of the Principality and the heraldic bull of Torino below. A naked male figure with a bull's head flank the central skyline, and a semi-clad female figure, bearing overhead a laurel wreath, is set between the freestanding columnar shafts on either side of the gate. The visual power of this construction would have been marred by the bastion which lay in front of it, as borne out by the contemporary engraving by Giovanni

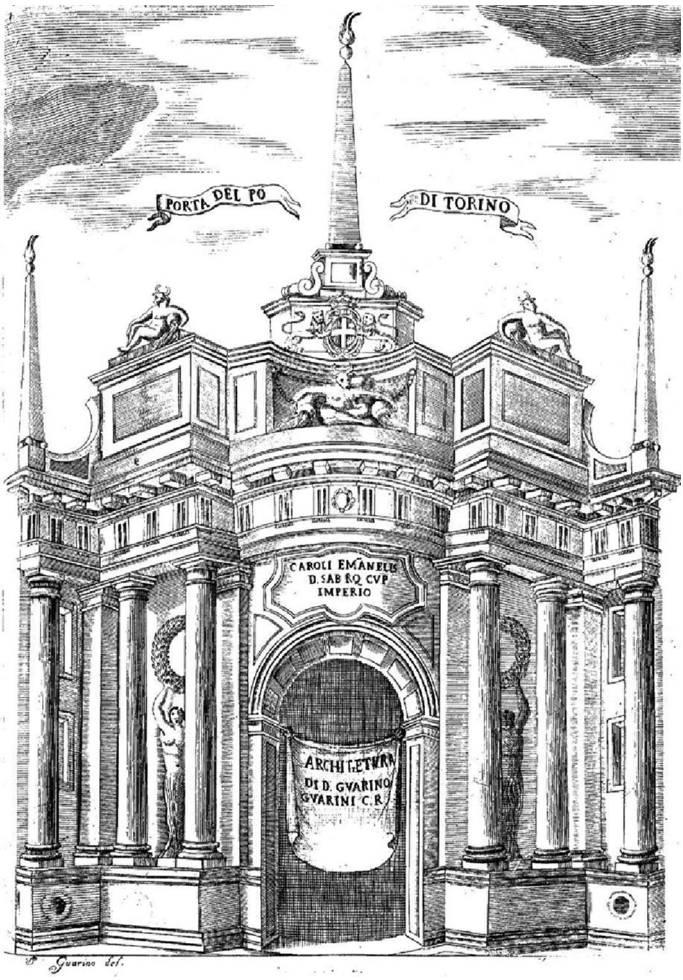

Fig. 4 Guarini's elevation of the Porta del Po di Torino, as shown in *Architettura civile* (Guarini 1737: not numbered)

Maria Maltese.[8] So Guarini may have been further consulted about the efficacy of the city's military architecture, usually kept secret in the interests of state security.

Text and Contents of the Treatise

What are fortifications? In the eleventh edition of the *Encyclopaedia Britannica*, an answer appears: "Fortification" is the military architecture of strengthening positions against attack.

[8] Maltese's engraving is based on a 1737 drawing by Ignazio Massone, and is conserved in the Archivio Storico della Città di Torino (Collezione Simeom, D 157). See: http://www.comune.torino.it/archiviostorico/mostre/barocco_2002/teca5.html (accessed 3 August 2014).

> Fortification consists of two elements, viz. *protection* and *obstacle*. The protection shields the defender from the enemy's missiles; the obstacle prevents the enemy from coming to close quarters, and delays him under fire…. Fortification is usually divided into two branches, namely *permanent fortifications* and *field fortifications*. Permanent fortifications are erected at leisure, field fortifications are extemporary building employing troops in the field, perhaps assisted by such local labour and tools as may be procurable, and with materials that do not require much preparation, such as earth, brushwood and light timber (Jackson 1910, pp. 679–80).

This is an important set of statements concerning the topic of fortification and siegecraft, informing us of the planning and constructional requirements required. Guarini's treatise is dedicated in an address to Ludovico Giulio, and after a notice to the reader, is composed of two Preludes and six Parts, with a few pages, illustrations and tables, and further full-page diagrams in twelve pages at the back. The following list sets out its textual contents: Prelude I. On Geometry, p. 5; Prelude II. On Arithmetic, p. 17; *Military Architecture*: Bk. I. Principles of Military Architecture, p. 33; Bk. II. Irregular Fortresses, p. 52; Bk. III. The planning and elevations of Fortresses, p. 68; Bk. IV. Planning Fortresses in particular places, p. 85; Bk. V. Attacking Fortresses, p. 103; Bk. VI. On Defence, p. 120. It is obvious that the Theatine covers the main aspects of constructing and running fortifications, and he does not ignore trigonometry, which is necessary to lay out polygonal forms as this topic may be needed. While four trigonometric tables with sines were included as an addendum to Prelude II, on Arithmetic, the textual treatment of this topic is found heading up Book IV, pp. 85–88. While where is nothing on the specific construction of such defences, it is quietly assumed that a prince would be aided in such matters by his assistants. The emphasis was clearly on the mathematical education of the pupil, so that Vauban's complaint about mathematics would be overcome. The overall treatment promises clarity and an able comprehension at first glance, partly indicated by the inclusion of basic trigonometry, surely following the published example of Dechales, and those of older experts such as the French knight, the Comte de Pagan, with his interior angles for a polygon of fixed side of 200 toises (Fig. 5).

Remembering what Jackson stated about fortification, here is how Guarini defined military architecture in Book I:

> L'Architettura militare è una scienza, la quale ha per officio di munire qualquque loco in tal guisa contro la forza ostile, che pochi possino resistere à molti imitando in ciò la natura, che munì molti loghi, e provincie, hor circondandole di scosese balze, hor'attorniandole di fiumi, e laghi, hor'inalzandole sopra le schene insuperabili di alpestri rupi (Guarini 1676: pp. 33–34).
>
> (Military architecture is a science, which has the duty of fortifying any kind of place against hostile force, so that few can resist many, in imitation of nature, which fortifies many places and provinces, sometimes surrounding them with crags, sometimes encircling them with rivers and lakes, sometimes raising above them impassable ridges of mountainous cliffs.)

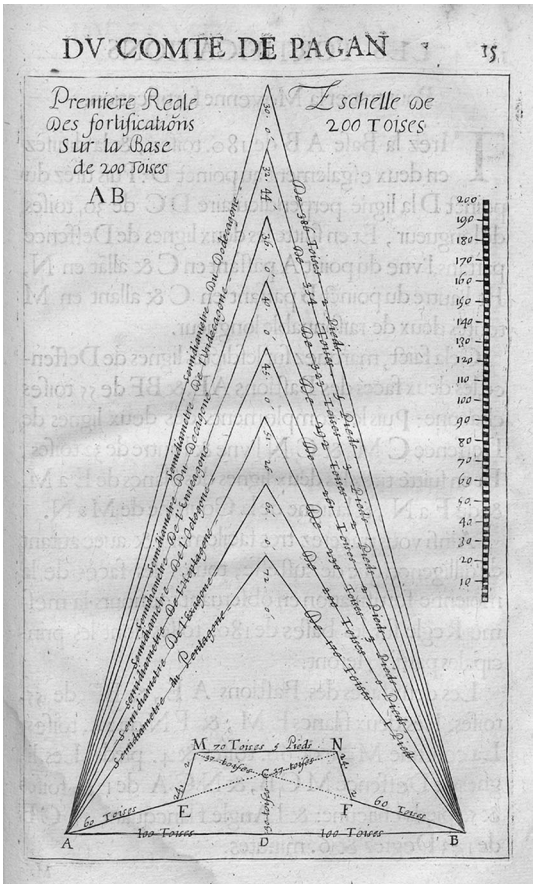

Fig. 5 Blaise François Pagan, *Fortifications.* Interior angles for eight sizes of polygon (Pagan 1645: 17)

Guarini portrays an imaginative depiction of protection drawn from the characteristics of nature, such as physical isolation and rugged environs.

Just as he was perhaps the first to look seriously at Gothic architecture against the classicist temper of the Renaissance, Guarini had a lively awareness of the danger of attack, and the rationality of defence based on natural refuges found across the geography of the world. This attention to such natural effects demonstrates clearly the application of Guarini's observational senses to the wider world, beyond the narrower confines of the abstraction of mathematics, which he already clung to with philosophical rigour in the pages of the *Euclides adauctus*.

The treatment of fortifications is geometrically determined, with swift enunciations of the main attributes of circumvallation, the geometry of the bastions, the planning of counterscarps, and the means of attack through mines and saps. The attractive feature of this account is the summation of doctrines in the twelve full-page illustrations at the end of the treatise. The reasonably detailed illustrations of these diagrams fulfilled Guarini's mission in writing the treatise (Figs. 6, 7, 8, 9).

But much as Guarini may be lauded today for his abilities and even genius as an architect, how did he become expert in military architecture? After this spirited introduction to fortification in his treatise, we do well to ask this question, as the Theatine was a theologian, poet, and mathematician, and not a member of the armed services. This is where the exemplary precedence of Dechales must be examined.

Tractatus vs. *Tratatto* Examined

Dechales was a prominent Savoyard Jesuit, and close to Guarini in general interests, such as mathematics, optics, gnomonics, astronomy, and architecture generally. More precisely, Guarini undertook a treatment of conic sections for use in architecture, mainly in vaults (Fig. 10), writing: *Tutti i volti nascono da sei corpi tondi, che tagliati per mezzo fanno sei sorte di Volti primi, ed elementary*' (All vaults are born of six round solids, which cut in half, make six sorts of primary and elementary vaults) (Guarini 1737: 183) (Fig. 10).[9] Dechales included something very similar in volume II of his *Cursus seu mundus mathematicus* (Dechales 1674).

In turn, Guarini may have copied Dechales's probable notion of architectural composition achieved through the dimensional amalgamation of elements such as separate solids as the beam or entablature, the column shaft, various mouldings, etc. (although since Guarini's *Architettura civile* was published posthumously, we are not certain who originated this particular theory). History has revealed little to connect these two writers, but certainly there is another link, in terms of military architecture. In Dechales's *Cursus* there is a *tractatus* presenting military architecture,[10] much of which is reprised by Guarini in his own treatise on fortifications. Indeed, the Book I of each are identical in content, namely on fundamental principles such as definitions of all the elements such as bastions, and a list of axioms. The Book II in each case diverged, with Guarini treating irregular fortresses, and Dechales regular. Books III and IV also differ, with Guarini on planning and elevations and on the use of trigonometry, and Dechales on outworks and on irregular planning. Both returned to the same topics for Books V and VI, on offensive fortresses. Dechales ended with Book VII on military perspective, while Guarini terminated with Book VI, with a discussion of presenting drawings and their colouring, a typical practice for an architect. There is a brief description of military perspective in *Fortificatione*. There is little doubt that both authors were working in parallel to some extent, and that Guarini did not have the flair in the field of military architecture to exhibit his usual expertise. Dechales was much more enthusiastic in presenting his material, as the diagram of a sectional rampart indicated. While Dechales dealt with algebra in the last *tractatus* in Vol. III, Guarini did not, so presumably they may have disagreed on certain directions of the contemporary development of the century. Both writers commented on the use of the tenaille, a fortified projection from the curtain wall with usually parallel sides, and Dechales

[9] For more on this, see (Badillo 2012: 71, notes 102–103).

[10] Dechales later published a French version, *Art de Fortifier*… (1677), due to his own popularity in the field of mathematics and its allied arts.

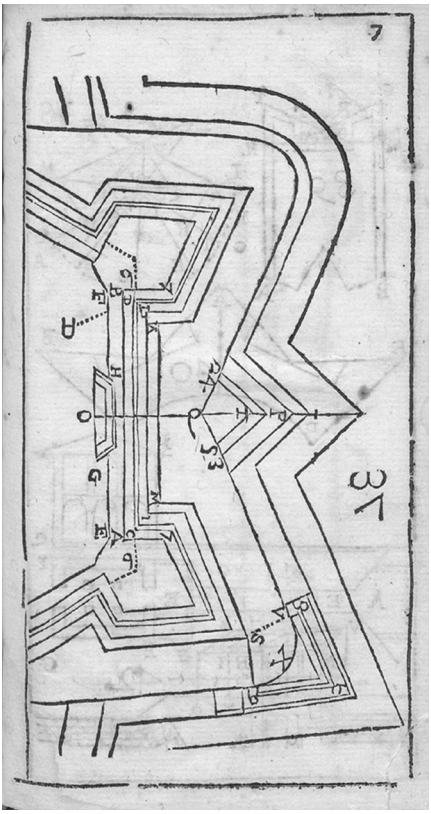

Fig. 6 Guarini, wall of fortification between two bastions, and external ditches (Guarini 1676: pl. 7)

has several plans of the complete stellation of fortifications, with tenailles. While Guarini confidently provided the detailed architecture for a city gate for Torino, as mentioned above and shown in Fig. 4, his actual experience was probably restricted in real life, for all that we can now determine.

Conclusion: Guarini and Nicolas-François Blondel

While Guarini might not have been a ranking military architect, he shared more general interests with Nicolas-François Blondel, a member of the French Royal Academy of Sciences, trusted friend of the French Court, advisor to King Louis XIV on fortifications, writer on architecture, artillery and the Roman calendar, and diplomat (McQuillan 1998). This military man was the first Director of the Royal Academy of Architecture, in 1671. More importantly, the two thinkers shared certain scholarly authorities in common. Guarini's favourite parts of mathematics were the theory of proportion, especially harmonic, and projective geometry, as he

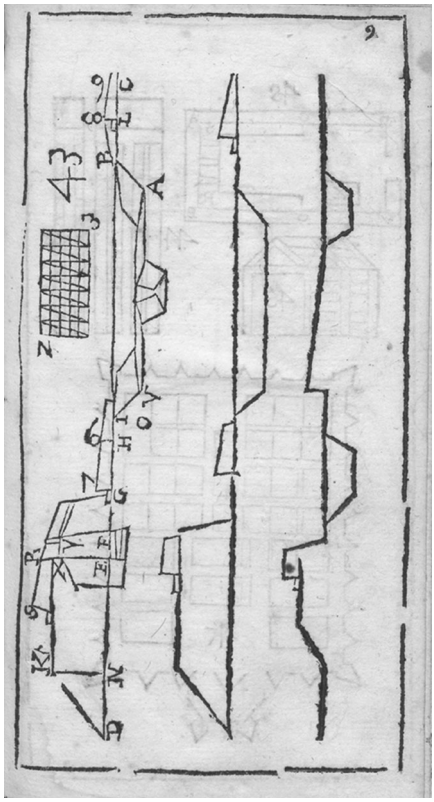

Fig. 7 Guarini, cross-sections showing profiles of walls and external ditches (Guarini 1676: pl. 9)

certainly understood the theorem of Pappus.[11] The Theatine shared a respect for the Jesuit Gregory of St. Vincent (1584–1687),[12] and both referred to this famous mathematician in their writings.[13] Guarini was convinced of the superior role of harmonic proportion as a great legacy of ancient mathematics, laid down by among others, Plato and Euclid, and developed ever since in Western mathematics. Blondel shared this belief, even under published attack from another courtier, Claude

[11] Pappus of Alexandria flourished between AD 300 and 350, and Guarini's presentation of his famous theorem is restricted to the use of major parallel lines, which do not need to be so according to Pappus. There is no evidence in Guarini's publications that, allowing for his concern with projection, he was aware of the specific teachings of Gerard Desargues, despite the allegations of some modern commentators in *Guarino Guarini e l'internazionalità del barocco* (see, for example, Mueller 1970). Blondel also understood the theorem of Pappus. For more on Guarini's mathematics, see (McQuillan 2009).

[12] Gregory of St. Vincent, a Flemish mathematician, wrote the *Opus Geometricum Quadraturae Circuli et Sectionem Coni* (Antwerp 1647), a claim to have squared the circle, which was shown to be false by Christiaan Huygens.

[13] Guarini did so in *Euclides adauctus* (1671: Tractatus XXVIII, p. 495), in the treatment of geometric progressions of areas, citing him by the name Ambrosius à S. Vincentio. Blondel followed Guarini by relating his admiration for the Jesuit mathematician, now correctly named, in his 'Resolution des quatres principaux problemes d'architecture', in the section where he discussed drawing machines for columnar entasis (Blondel 1676, p. 10).

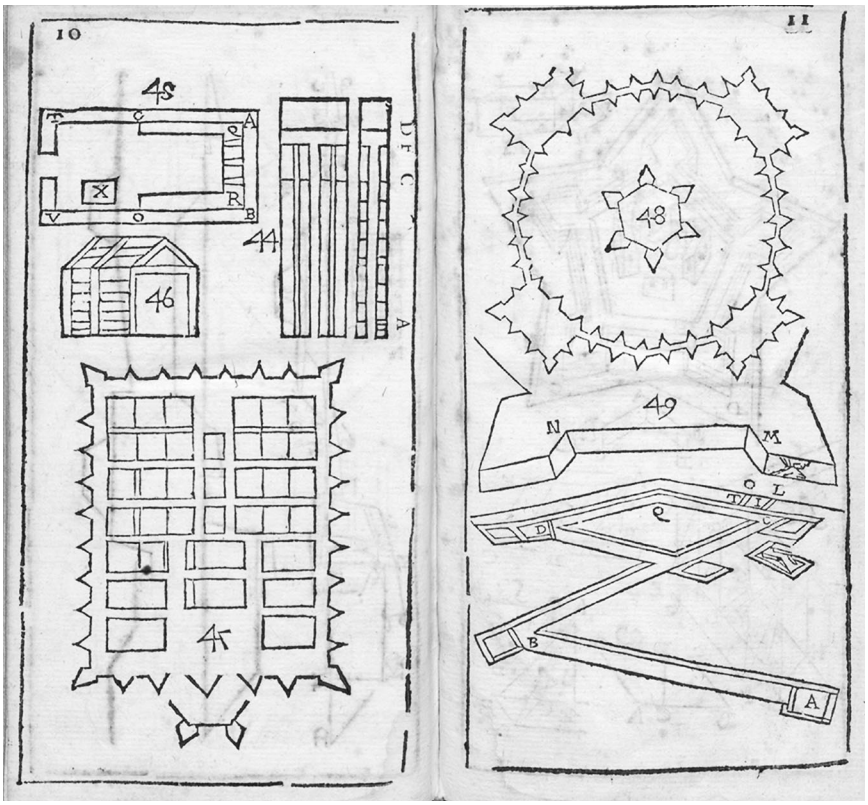

Fig. 8 Guarini, *left* Rectangular fortified barracks; *right* circular fortress with hexagonal central citadel, and external ditches (Guarini 1676: pls. 10–11)

Perrault, who may not even have fully understood the rationale of harmonic proportion. This was an intellectual battle between different authorities, known later as the *Querelle des Anciens et des Modernes* (Quarrel between the Ancients and the Moderns). Perrault was a physician, and his mathematics were not marked. Thus he relied on custom and habit for his belief in the origin and application of proportion, not based on rigid rules, a factor that may not have been deeply questioned with respect to this courtier.

The result of this battle was that the supporters of the Ancients lost their cause, and both music and architecture eventually shed their shared belief in a universal system of proportions, especially that of harmonics, to the Moderns. Blondel also believed that 'one well-thought system [of fortification] should prove effective in all circumstance' (Vuillemin 2008: 160), against Vauban, who preferred to design a fortification specific to its particular site. This was the stance that Guarini observed in terms of an existing city or town, but never proclaimed this belief in a general

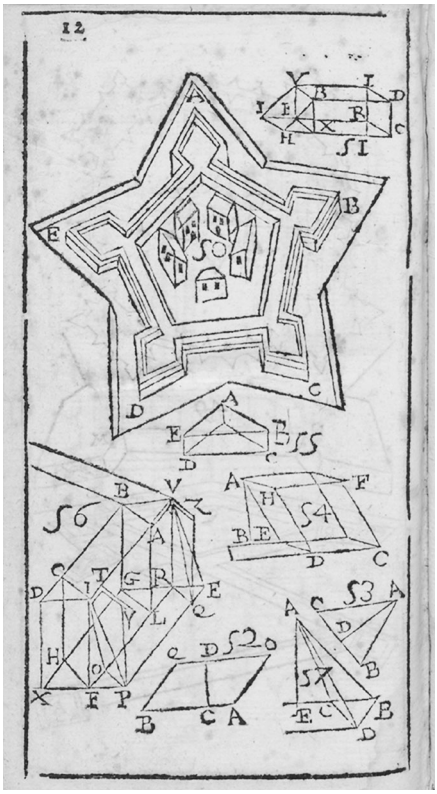

Fig. 9 Guarini, pentagonal fortress with five central barracks (Guarini 1676: pl. 12)

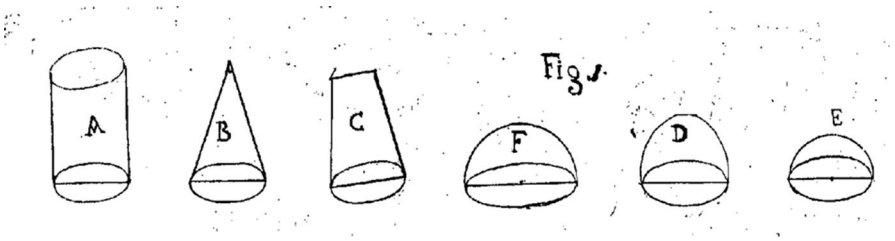

Fig. 10 Guarini's illustration of the six 'corpi tondi' used for vaulted structures (Guarini 1737: Lastra 19, Trat. 3, Fig. 1)

statement of practice, as did his French 'companion-in-arms', Blondel, in such very definite terms, contrary to the master of fortifications, Vauban.

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