The Science of Fortification in Malta in the Context of European Architectural Treatises and Military Academies

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In order to understand why the fortifications of Malta evolved as they did, we need to study them in the context of the technical publications and military academies of the period. The science of fortification that developed during the three-century presence of the Knights on the island is a European science and the result both of theoretical debate and practical trials. This debate, which went on in military academies and in a variety of texts, discussed the merits and limitations of different models of attack and defence.

By 1530, when the Knights of Saint John of Jerusalem landed in Malta, the invention of the press and the Renaissance rediscovery of the architectural ideals of antiquity had already contributed to the dissemination of a few texts on tactics and military construction. One of these was *Comitis epitoma rei militari* by Renatus Flavius Vegetius, written in the fourth century and subsequently copied and recopied in manuscript form. The book was printed for the first time - still in Latin - in Cologne around 1475, and later translated at various times into Italian, French, German, English and Spanish, right up to the end of the eighteenth century. The text gave information on the main conditions for fortress construction, in particular in books XXII to XXV:

> XXII. In qualibus locis constituenda sint castra (on the location of a fortress)
> XXIII. Quali specie castra delinianda sint (on the design of a fortress)
> XXIIII. Quo genere munienda sint castra (on the type of equipment for a fortress)
> XXV. Quemadmodum munienda sint castra, cum hostis immineat (on the way a fortress should be equipped).
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> (Vegetius *ca*. 1475, index)

There were a few other works from classical antiquity available at that time, which gave information on methods of fortification, tactics, military machines and troop encampment. These books included: Pliny's *Naturalis historia* (23-79AD), printed for the first time in Venice in 1469; *Liber X* from Vitruvius's *De architectura* (first century BC), available in print from 1486 on; *De militia romanorum*, by Polybius (*ca* 203 BC - 120 BC), published in 1521; *De militia et castrametatione romanorum* by the same author, translated from the Greek and published in 1551 and the *Liber de munitionibus castrorum* by Hyginius Gromaticus (second century BC), published in 1554.

At the same time, new authors, following a structure similar to that of the ancient books, began to produce technical literature on the *modern* art of fortification, explaining the formal and spatial

design rules and the latest offensive and defensive strategies. One such work was *De re militare libri XI* by Roberto da Rimini Valturio which came out in several editions from 1483 until 1534. Another was *L'opera nuova,* by Achille Marozzo, which was available in various editions between 1536 and 1550. In these books, special emphasis was given to the technique of constructing foundations with discharging arches able to withstand sapping. Defensive walls reinforced with buttresses and arcades from the inside were also discussed in detail. The art of mining, which had already been used in 1503 by the Spanish at the Siege of Naples, and in 1522 by the Ottomans at the Siege of Rhodes, was made possible by the introduction of gun powder. A detailed description of techniques for its use was given in Nicolò Tartaglia's *Nuova scientia inventa*, published in Venice in 1537 for the first time, and subsequently translated into French and English.

Along with the development of mining, the development of artillery had determined the need for the construction of defensive ramparts made of earth or masonry able to withstand the impact of canon balls. The development of artillery also gave rise to the construction of obtuse re-entrant-angled bastions from which it was possible to view and defend different rampart sectors. Advances in geometry and mathematics revealed the ideal geometric shapes for bastions and the appropriate orientation of the walls of defence. These improvements were presented by authors, who not only wrote on pure geometry and mathematics, but were also concerned with the practical design of fortifications. These included Albrecht Dürer with his *Etliche underricht zu befestigung der stett, schloss und flecken,* (1527), Giacomo Lanteri with *Nel modo di disegnare le piante delle fortezze secondo Euclide*, (1557-59) and Johannis Geyser and the *Architectura militaris,* (1553).

The texts mentioned above, were a definite influence on the new defensive constructions erected in Malta by the Hospitallers, not only the new Fort St. Elmo, built in 1552 to a symmetrical star-shaped plan with very acute angles, but also the reinforcement of the fortifications built prior to the Knights' arrival on the island. These first works were generally entrusted to local engineers or to visiting Italian engineers **(table 1)**, often in the service of the Viceroy of Sicily (Hoppen 1981). As in the rest of Europe, these works were associated with the adaptation of medieval constructions to the needs of contemporary artillery: - the reduction of the towers in height; the demolition of the old crenellation; the construction of new bastions, ramparts and embrasures through which guns could be fired. Also undertaken in this first series of defensive works was the construction of a new cavalier for Fort St. Angelo in 1554, which would allow the bombardment of the Grand Harbour mouth.

After the Great Siege of Malta in 1565, the urgent need to rebuild Fort St. Elmo, and to construct an impregnable fortified city (La Valletta) heralded a new phase in the island's defences. These new works were undertaken at a stage when the debate on fortress design was focussing on ever more specific problems.

The new essays debated the angle width between bastion flanks and curtains, the nature of the line of defence (based on the angle of fire of the canons), the distance between two adjacent bastions (within the range of either a musket or a cannon-shot), the number of sides on the polygonal

fortification plan, the parapet width, the dimensions for ditches, glacis and caponieres, the thickness of ramparts whether of earth or masonry, the height and width of the counterscarps. In addition, there was practical information on how to build temporary fortifications fast, the so-called *opere da soldato* which included redoubts, palisades, breastworks and trenches, like the ones that had been so pivotal in the defence of Malta during the Great Siege. These temporary constructions and the evolution of the Great Siege battles are described in deep detail by Francesco Balbi da Corregio in his memoirs *La verdadera relación de todo que el anno de MDLXV ha succedido en la Isla de Malta*, printed in Barcelona in 1568. (Corregio's account of the fortifications was recently discussed in Marioni and Loffredo 2001).

Table 1 –Fortresses in Malta; Engineers and Grand Masters and the period of their activity. (Nationalities are abbreviated and given in parentheses) (Spiteri 2001)

Malta fortresses	1530 - arrival of the Knights; 1541 – new cavalier on old Fort St. Angelo; 1552 – Fort St. Elmo is built; 1565 – Great Siege; 1566 – new Fort St. Elmo construction begins; 1570 – plan for La Valletta; 1614 - widening of the ditch and construction of the Vêndome bastion in St. Elmo; 1615 - La Valletta aqueduct finished; 1635-90 - La Valletta's curtain construction; 1669 – crownwork at Floriana Line; 1670-80: Cottonera Line; 1670-98 - Fort Ricasoli construction; c.1680- integration of Fort St. Elmo in the Floriana Line; 1697-1721 - Fort St. Elmo reinforced; 1726 - Construction of Fort Manuel; 1792-94 - Fort Tigné is built; 1798 - French invasion. Fort Ricasoli resists against three French attacks.
Malta engineers	1532-35: Piccino (I); 1535-41: Ferramolino (I); 1552 :Prato; 1554: Bellavanti (I); 1558-32: Genga (I); 1560-67: Manga (I); 1560-90: G. Cassar (M); 1562: Lanci (I); 1565: Lanci (I); 1565: Vitelli (I); 1566: Serbelloni , Palearo and Campi (I); 1566-70: Laparelli (I); 1576: Floriani (I); 1590-1607: Cassar (M); 1599: Rinaldini (I); 1632: Dingli (M); 1635-38: Floriani (I); 1635-59: Buonamici (I); 1638: Da Firenzuola (I); 1640: Medici (I); 1645: Pallavicino (I); 1645-46: Guazzo (I); 1645: F. de Pagan, d'Arpajon and Clerville (F); 1659-98: Blondel (F); 1670-71: Valperga (I); 1681-90: Grunenberg (B). 1703: Colongues (F); 1706-38: Carapecchia (I); 1708 : Hecker (SE); 1713-15: Bachelieu (F); 1714-15: Tigné (F); 1715-19: Mondion (F); 1715-16: Vendôme (F); Tressemane (F); Folard (F); Maigret (F); 1720-33: Mondion (F); 1727-62: Marandon (I); 1761: Bourlamaque (F);Thomas Valperga di Caluso (I); 1793-98 - Stephen de Tousard.
Malta Grand Masters	1521-34: L'isle Adam (F); 1534-35: Del Ponte (I); 1535-36: Saint Jaille (F); 1536-53: Homedes y Coscón (E); 1553-57: La Sengle (F); 1557-68: La Vallette (F); 1568-72: San Savino (I); 1572-81: La Cassière (F); 1581-95: Verdalle (F); 1595-1601: Garcês (E); 1601-22: Alof Wignacourt (F); 1622-23: Vasconcellos (P); 1623-36: Paule (F); 1636-57: Castellar (F); 1657-60: Cruzat (E); 1660: Clermont-Gessant (F); 1663-80: Cotoner y Oleza (E); 1680-90: Roccellla (I); 1690-97: Adrien Wignacourt (F); 1697-1720: Perellós y Roccaful (E); 1720-22: Zondadari (I); 1722-36: Vilhena (P); 1736-41: Montenegro (E); 1741-73: Fonseca; 1773-75: Tejada (E); 1775-97: Rohan de Polduc (F); 1797-99: von Hompesch (D).

There were a number of books on constructing fortifications wherever they were needed and whatever the terrain **(table 2)**. Notable among these was *Nuova inventione di fabbricare fortezze di varie forme, in qualunque sito di piano, di monte, in acqua*, by Giovanni Battista Belici, published in Venice in 1598.

At the same time, the question of how to build the best-fortified city had already been studied with regard to Rome, Florence, and Lucca. In the case of Malta, the construction of La Valletta was taken as an ideal opportunity to start from scratch with all the latest theories, while retaining the existing forts of St. Elmo and St. Michael as the main outwork redoubts.

Several Italian books, widely circulated at the time, were available as reference material for the construction of fortified cities, including Zanchi's *Del modo di fortificare le città* (1559), or *Della fortificatione delle città*, by Maggi and Castriotto (reprinted 1564-84). These treatises were followed by others - by Cataneo, (printed and reprinted between 1571 and 1608), Lupicini (reprinted 1582-1601), Ramelli (reprinted 1588-1620) and also, translated into French and German, Scala (reprinted 1596-1627), Lorini (reprinted 1597-1621), Busca (reprinted 1598-1619) and De Marchi, this last one a true publishing success, with a first edition in 1599 and successive reprints up to the beginning of the nineteenth century.

Table 2 - The sixteenth century. Published books with wide circulation by country of origin. Languages of translations are given in parentheses.

	Military treatises and their periods of circulation
Italy	1483-1534: Valturio, *De re military*; 1483-1534: Valturio, *De re militari*; 1536-50: Marozzo, *Opera nova*; 1537-1845: Tartaglia, *Nuova Scienza* (F) (UK); 1550-68: Marozzo, *Arte delle armi*; 1557-1601: Lanteri, *Del modo di disegnare le piante delle fortezze*; 1559: Zanchi, *Del modo di fortificare le città*; 1564-84: Maggi, Castriotto, *Della fortificatione delle città*; 1570: Alghisi, *Delle fortificationi*; 1571-1608: Cataneo, *Dell'arte militare*; 1576: Floriani, *Discorso intorno all'isola di Malta*; 1582-1601: Lupicini, *Architettura militare*; 1588-1620: Ramelli, *Le diverse e artificiose machine* (F) (D); 1591: Zinano, *Il soldato over della Fortezza*; 1596-1627: Scala, *Delle fortificazioni*; 1597-1621: Lorini, *Delle fortificationi* (D); 1598-1619: Busca, *Della architettura militare*; 1599-1810: De Marchi, *Della architettura militare*.
France	1548-92 : Du Bellay, *Instructions sur le faict de la guerre* (I), (UK) ; 1598: Bachot, *Le gouvernail…l'architecture des fortifications*.
Spain and Portugal	1568-96: Londoño, *Libro del arte militar*; 1583: Escalante, *Dialogos del arte militar*; 1598-1613: Rojas, *Teoria y practica de fortificacion*; 1599: Gonzalez de Medina, *Examen de fortificacion*.

	Military treatises and their periods of circulation
Great-Britain	1589 - Ive, *The practise of fortification*; 1579-90: Digges, *An aritmeticall militare treatise;* 1598-1629: Barret, *The theorike and pratike of moderne warres*.
Germany	1487-1779 – Vegetius, *Epitome rei militari* (L) (I) (F) (D) (UK) (E);

In addition to the Italian treatises, there were new Spanish ones which definitely influenced the fortification system adopted in the island since, in the second half of the sixteen century, the chief engineers in Malta, though of Italian origin, were in the service of the King of Spain **(table 1)**. Notable among these Spanish works, are those by Lodoño, Escalante, Cristobal de Rojas and Gonzalez de Medina. Similarly influential works in other languages include the French essay by Du Bellay, *Instructions sur le fait de la guerre,* reprinted between 1548 and 1592, the English manual *The practise of fortification* by Ive Paul (1589 onwards) and the German *Architecture von vestungen* (in different editions from 1589 to 1608).

As more and more military treatises were published towards the end of the sixteenth century, the increasing importance of the military engineer's role was paralleled by the creation, all over Europe, of Engineering Corps initially responsible for sap and artillery action. The officers of these corps spent their time not only on tactics and military defence and offence, but also on ballistics, on fortress design and on the production of military maps. With time, their work came to include the production of civil maps to be used in the construction of canals, roads, harbours and bridges (Veltmann 1979, pp.263-79). It is therefore not surprising to see the completion of the Valletta aqueduct, at the beginning of the seventeenth century - a time of relative peace in Malta.

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In the second half of the seventeenth century, the role of engineer received a big boost with the creation in France by Sully, in 1676, of the "Corps des Ingénieurs", directed by Sébastien le Preste de Vauban, "ingénieur du Roi" and field-marshal of Louis XIV's army. This corps was immediately assigned to territorial management, border definition, and the castrametation of French territory, all-important for reinforcing the new absolutist model of government. This training model was soon copied all over Europe so that, for almost two centuries, western military architectural books reflected the following innovations that came in with the adoption of the French model:

- The training of military engineers with an eclectic package of skills including military tactics, mathematics, geometry, topography, hydraulics, military and civil constructions;
- The widespread use of polygonal systems of fortification theorized by De Ville, Pagan (who visited Malta in 1645) and Vauban.

At the same time, in the Netherlands (scene of the Thirty Year War from 1618 to 1648), other models were developed, especially adapted to mud flats, alluvial and coastal terrains, and harbours

defended by sluices, floodgates and iron chains. In consequence, methods like those of Stevin, Hondius, Marolois and van Schooten, Freitag, Goldman, Dögen and Melder were translated into a variety of languages and thus acquired a wide readership (**table 3**).

All these French and Dutch systems originated in two concepts which were much discussed at the end of the sixteenth century by Italian authors such as Francesco de Marchi (designer of the pentagonal-shaped Antwerp citadel, in 1567) and Bonaiuto Lorini. The first concept advocated polygonal fortification as the most suitable for fighting from a long distance, while the second one advocated fortification with angular bulwarks for close combat. (Borgatti 1898, pp.10-15).

The first widely accepted model of a *modern* fortified city, built at Palmanova in 1593 with a central plaza and radio centric plan, underwent a quick evolution and was replaced by polygonal-shaped plans: triangular plans with whole or half detached bastions; squared plans; star-shaped plans with whole bastions, half bastions or tenailles; in addition to pentagonal, hexagonal or half hexagonal plans with or without strengthened tenailles. The possibilities for outworks consisted of ravelins (either single, with counterguards, or strengthened with detached lunettes), spurs, mezzalunas (demi-lunes), tenaillons, hornworks, crownworks and crowned-hornworks. Each of these could be placed ahead of the main enceinte according to the orographical conditions and the desired firing range.

These design concepts featured specific values for the angle between the faces and the flanks of the bastions, and geometrical proportions for the bastions' necks (gorges), orillons, cavaliers, parapets, traverses, battlements, ramparts, glacis, ditches and counterscarps. These could be fitted with wooden platforms called banquettes on which guns were mounted to withstand the "modern fire" called ricochet (Borgatti 1898, pp.10-15). Methods for offensive fortification focused on forms of encampment, bypass, siege laying, counter-offensive, attacking batteries, sap and gallery construction techniques, mining and assault.

Table 3 offers the principal seventeenth-century books to transmit the most important national variants of these fortification systems. All of these books were reciprocally influenced and influential. Due to their frequent reprints, citations, and translations into a variety of foreign languages, special mention should be given to *Les fortifications* (issued between 1628 and 1672) and *De la charge des governeurs de places* (reprinted from1639 till 1708), both by Antoine de Ville; *Les fortifications* by Blaise François de Pagan, (printed from 1645 till 1689); *Les travaux de Mars* by Manessont Mallet (reprinted 1671-84); *La nouvelle manière de fortifier les places* by François Blondel (reprinted 1683-1711); the same title by Arnold de Ville (reprinted 1689-1748); *Véritable manière de bien fortifier,* by Vauban, firstly published in 1692 and then translated into French, Italian, English, German and even into Turkish in 1794; the *Traité de fortification* (reprinted 1694-1711) by Ozanam and finally the *L'ingénieur français*, by Naudin, published between 1695 and 1757.

Also from the seventeenth century, representative authors of the "Spanish School" should be noted, for instance: Santans y Tapia, Fernandez de Villareal, Mut, Folch de Cardona and Fernandez de Medrano. The English authors Gunter and Moore and German ones such as Dillich, Böckler and Pfeffinger also attained wide circulation and were translated into French. Among the "Italian School" can be found authors like Pelliciari, Capo Bianco, Sardi, Floriani, Fiorenza, Tensini and Paggi. Furthermore, Guarino Guarini (with the *Trattato di fortificatione, che ora si usa in Fiandra, Francia, & Italia*, published in 1676), Capra, Amichevoli and Alimari, produced works that received broad distribution.

Table 3 - The seventeenth century. Published books with wide circulation by country of origin. Languages of translations are given in parentheses.

	Military treatises and their periods of circulation
Italy	1600-19: Pelliciari, *Avvertimenti militari* (F); 1601-09: Busca, *Architettura militare*; 1602-92: Bianco, *Corona militare* (D); 1618-44: Sardi, *Corona imperiale* (D) (F); 1621-89: Sardi, *L'artigleria*; 1624-30: Tensini, *La fortificazione*; 1630-54: Floriani, *Difesa et offesa;* 1645: Fiorenza, *Il curioso* (F); 1676: Guarini, *Trattato di fortificatione;* 1683: Capra, *Nuova arch. militare;* 1684: Amichevoli, *Architettura militare*.
France	1600-21: Errard, *La fortification*; 1628-72: Deville, *Les fortifications*; 1639-1708: Deville, *De la charge des gouverneurs* (P) (D); 1645-89: Pagan, *Les fortifications*; 1648-61: Fournier, *Traité des fortifications* (E); 1671-84: Mallet, *Les travaux de Mars*; 1683-1711: F. Blondel, *Nouvelle manière*; 1689-1748: Ville, *Nouvelle manière de fortifier* (UK); 1692-1769: Vauban, *Véritable manière de bien fortifier* (I) (UK) (D) (T); 1692-1723: Fer, *Fortification;* 1695-1700: Fer, *Plan des villes et places de l'Europe*; 1694-1711: Ozanam, *Traité de fortification* (UK); 1695-1757: Naudin, *L'Ingénieur françois*; 1697-1745: St Remy, *Mémoires d'artillerie* (UK).
Spain	1649: Villareal, *Architettura militar*; 1651: Villegas, *Academia de fortificación*; 1664-94: Mut, *Arquitectura militar;* 1669: Cepeda y Adrada, *Epitome di fortificación;* 1671-81: Cardona, *Geometria militar*; 1687-1700: Medrano, *El Ingeniero* (F).
Portugal	1622 – Turriano, *Dos discursos sobre el fuerte* (E); 1650-80 - Pimentel, *Methodo Lusitanico.*
The Netherlands	1614-62 : Marolois, Van Schooten, *Fortification* (F), (D), (UK); 1612-18 : Stevin, *Nouvelle manière* (NL) (F); 1624-25 : Hondius, *Reglen der fortificatie* (F) (UK); 1631-65: Freitag, A*rchitectura militaris* (L) (NL) (F) (D); 1645 : Goldmann, *La nouvelle fortification* (NL) (F); 1647-1780: Dögen, *Architectura militaris* (L) (NL) (F); 1658-64: Melder, *Instructie van de Fortificatie.*

	Military treatises and their periods of circulation
Great Britain	1635-80: Gunter, *New treatise of fortification*; 1645: Papillon, *A practical Abstract*; 1673-89: Moore, *Modern fortification.*
Germany	1641: Treu, *Compendium fortificationis* (L) (D); 1666: Ruse, Melder, *Praxis fortificatoriae* (L) (D); 1659-1714: Böckler, *Manuale architecturae militaris* (L) (D); 1688-1740: Pfeffinger, *Mathematiche Aufgaben* (F) (P); 1689: Heer, *Theoria artis muniendi* (L) (D).

Between 1635 and 1645, Pietro Paul Floriani's work on the new curtain for La Valletta known as the Floriana Line, with its bastioned front composed of a central bastion, two half bastions, two ravelins, a faussebraye in front of the main curtains, counterguards and lunettes, demonstrated the strong influence of Dutch models proposed by Hondius and Freitag (Marioni and Loffredo 2001, p.61). During the second half of the seventeenth century, Malta employed French and Dutch fortification models not only because of the well-known treatises from those countries but also because of the presence of visiting and resident French and Dutch engineers, particularly Médéric Blondel, between 1659 and 1698 and Carl Crunenberg, between 1681 and 1690 (Hoppen 1981, pp. 413-33).

A new and important phase of fortifications in Malta began in 1669, partially in response to the Ottoman occupation of Candia (Crete). A decision was made to reinforce the Floriana Line with what essays of the period claimed to be the most effective external work, the crowned hornwork. Fear of a possible Ottoman siege moved the Knights to construct a new line of defense (the Cottonera Line) on the other side of the harbour, opposite to La Valletta; this design circumscribed the hills of Sta Margherita and San Salvatore, and the half finished Margherita Line. The Cottonera Line with eight bastions was drawn up according to plans *all'olandese* and thereby adhered to Dutch fortification methods (Spiteri 2001, pp.295-96). Designed by the Italian Count Antonio Maurizio Valperga, this project was built without the projected cavaliers, ravelins and covertway, due to alterations introduced by the French engineer Médéric Blondel who, in addition to overseeing the project's construction, was a follower of the Vauban principles. In 1670, this same Count Valperga combined the Italian and Dutch systems in his designs for Fort Ricasoli on the promontory facing St. Elmo on the other side of the Grand Harbour entrance. Initially the fortress was constructed with a central bastion, two half bastions, two ravelins, a faussebraye, a covertway and a ditch on the landside. Then, in 1698, the fort was strengthened on the coastal side with a low tower and battery and on the landside with additional traverses on the faussebraye, a casemated redoubt and a covert-way. These were added according to proposals from the French engineers Tigné, Mondion and Vendôme. During the same period, 1680, Fort St. Elmo was integrated with the Floriana Line.

During this period of great construction in Malta, the theoretical discussion of fortification design became more complex. The advantages found in the approaches to fortification put forward by De

Ville, Pagan, and Vauban overtook the Dutch, Italian and Spanish methods. In turn, the fortification theory was subdivided into two main classifications, one based on regular shapes and the other on irregular shapes. To give some idea of the range of recommendations, De Ville, for example, advocated a method that resulted in a theoretical increase in the defence line proposed by the Dutch system, from 118 to 135 fathoms (1 fathom = 2 yards = 1,83m). De Ville also recommended acute bastion shoulders for plans based on squares and pentagons and straight angles for hexagonal plans or for polygons with more than six sides. Pagan, in contrast, put less emphasis on bastion's shoulders. Instead, he demanded a defence line that offered low shot along its entire length. And lastly, De Ville recommended a piazza bassa and bastions with flanks and face lengths equal to the sixth part of the side of the inside main polygon The bastion orillons, on the other side, should have a length equal to two thirds the bastion flanks. Pagan foresaw three fortification categories: large ones with curtains 180 fathoms long; average ones with 162 fathoms; and small ones with 144 fathoms **(fig. 1)**.

But, the real creation of the new seventeenth century systems of fortification has been attributed to Vauban, who presented three variants on a grid of bastions positioned around the polygonal fortress. In the first variant, each of the bastion faces was covered by the fire of the artillery posted on the adjoining bastions. In the second variant, each bastion was positioned independently and at a higher altitude in relation to the main curtain. In the third variant, all of the bastions were open to the fire of the main polygonal fortress and their number was multiplied to increase the quantity of defence presented to the enemy (De Hallé and Groestschel 1983).

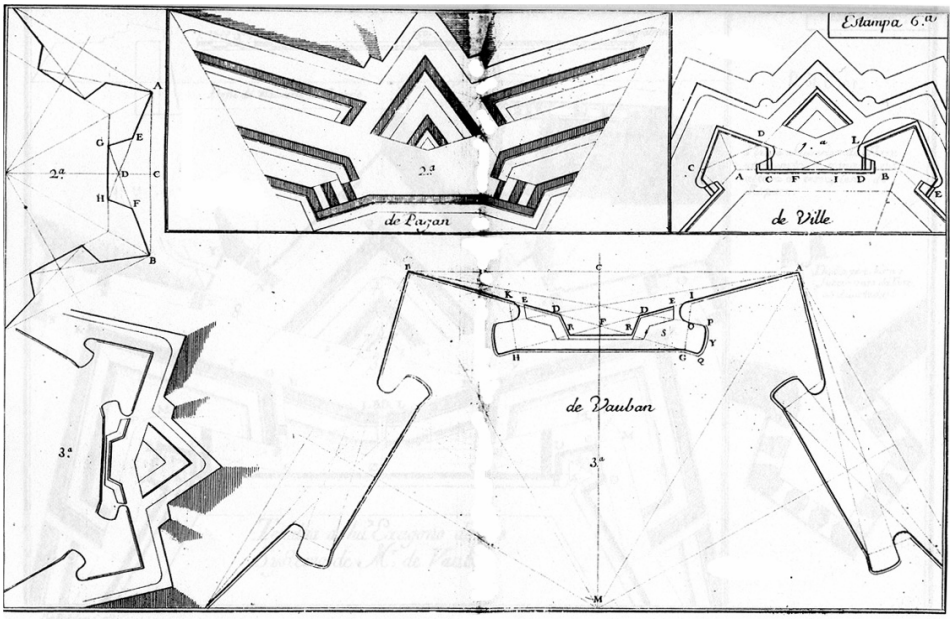

Figure 1. Comparison between the systems by Pagan, De Ville and Vauban (Fortes 1729, fig.6a).

The establishment of military academies in many European countries both paralleled and fuelled these debates about security (Mateus 2003, pp. 1390-91). With the development of these schools, lessons, résumés and academic manuals came a new typology of technical literature. This military and defence training became also more and more autonomous, thereby supporting the delineation of new, specific professional roles. In this respect, the French model was preferred once again. After the foundation of the "Académie Royale d'Architecture" in 1671 and the creation of the "Architecte du Roi" title for its members, France set up the "Corps d'Ingénieurs" within the "Corps des Ponts et Chaussées" in 1716. Subsequently, the "École des Ponts et Chaussées", established in 1747, trained the "Ingénieur de l'État", a position explicitly responsible for public works as well as being the predecessor of today's civil engineer (Picon 1988, pp.86).

In tandem with these successive professional divisions, the new practice of encyclopaedic classification made an important contribution. It consolidated different sectors of knowledge: History, the Liberal Arts, Philosophy, Mechanics and Theoretical Sciences and included Mathematics and Mechanics with the Sciences since them all focused on the application of Reason. Architecture itself came to be seen as having three distinct categories: civil, military and naval (Roth 1769).

As the roles of engineer and civil architect became more distinct, works that addressed the requirements of both civil and military architecture disappeared. The most influential of these books that dealt with a unified, vanishing discipline was Alessandro Capra's *La nuova architettura civile e militare*, published in Cremona in 1717; and this tome itself represented the "fusion" of two earlier works, *La nuova architettura famigliare*, printed in 1678 and *La nuova architettura militare d'antica rinnovata* , from 1683.

As time passed, texts for military architecture grew more selective in their content. They focused on visual presentation, providing mainly sketches of plans and profiles for the most modern fortified systems. In general, discussions and explanations of common constructional problems were reserved for treatises on civil architecture and only complex problems such as the determination of vault thickness for casemates, were explained in military treatises.

From this same period, the main texts used in the military academies should be noted. The course books used most frequently were by Saint-Julien, by Bélidor (the first director of Architecture at *École des Ponts et Chaussées*), by Desprez de Saint-Savain, and by Le Blond and Fallois. Other important eighteenth-century French authors in this field were, in chronological order, Barnaud, Lécuyer de la Jonchère, Bombelles, Naudin, Deidier, Dupain de Montesson, Quérelles, Pazzi de Bonneville, Cugnot, Julienne de Belair and Briche **(table 4)**. Moreover, English and German essays had a wide European readership due to translations of Bodenehr, Herrmann, Robbins (who wrote an important reference book on artillery), Muller, Brühl, Horst and Tielke. And the Italian authors of consequence at this time were Aquino, Biagio Amico, Soliani Raschini, Fonda, Borgu, Salimbeni and Papalino d'Antoni.

Despite the quantity of texts mentioned, only a few published works offered a geographically broader vision of European defensive systems. Malta system of defence was represented in *Les Forces de l'Europe ou descriptions des principales villes avec leur fortifications* **(fig. 2)**, published in 1695 by De Fer, Luis XIII'geographer, and lately appeared in the *Traité de la sûreté des états…par le moyen des fortresses*, by the engineer Philippe Maigret who visited Malta between 1715 and 1716.

The eighteenth century **(table 4)** was additionally marked by the institution of new systems that resulted in the more economic use of building materials in defence construction and in better adaptation to existing site conditions for foundations. The Dutch system of Coehorn (first published in 1702), for example, argued for a long line of defence. The Rozard system, dating from 1731, instead proposed bastions of great dimensions and short curtain lengths defended by casemates positioned in order to defend the ditch with a low shot of artillery. In 1741, the Cormontaigne system centred on the least number of artillery pieces needed for efficient defence.

Figure 2. Malta fortifications (De Fer, 1695).

The second half of the century was characterized by the perpendicular system promoted by Marc René Montalembert. Made possible by the longer range of recent cannons, this system brushed aside the tenet of covering the defence line with low shot and as a substitute proposed the mutual

defensive fire of a network of forts. This arrangement should project outwards from the main curtain and provide enfilading fire from the flank of the bastions along the faces of the adjacent works. The system was disposed along either a polygonal or circular line and took into account the fire at differing heights from new bomb-proof casemates.

Within this rapidly evolving theoretical context, new fortifications were built at Malta in the Marsamxett Harbour, opposite to the Grand Harbour. The projects for Fort Manuel and Fort Tigné were then considered regular fortifications, since they had neither been adapted to pre-existing medieval constructions nor been integrated with defensive curtains.

At the time of its construction, from 1723 to 1732, by the French engineer Mondion, Fort Manuel represented the cutting edge of fortification design. Built on an island in Marsamxett Harbour, the fort had a basic, squared shape and four corner bastions, two of these on the land side. It also possessed communicating cavaliers, a low profile curtain able to optimize the effect of cross fire and several bomb-proof vaulted casemates capable of accommodating 500 soldiers in the event of a siege.

Table 4 - The eighteenth century. Published books with wide circulation by country of origin. Languages of translations are given in parentheses

	Military treatises and their periods of circulation
Italy	1717: Capra, *La nuova architettura civile e militare*; 1724-34: D'Aquino, *Lexici militaris*; 1748: Soliani Raschini, *Trattato di fortificazione moderna*; 1764: Fonda, *Elementi di arch. civile e militare*; 1777: Borgu, *Arte della fortificazione*; 1781-1816: d'Antoni, *Dell'architettura* (P).
France	1705-13 : Saint-Julien, *Méthode des ingénieurs* (D); 1719-46: Bombelles, *Journalier d'infanterie* (P); 1721: Maigret, *Traité de la sûreté des états*; 1729-1830 : Belidor, *La Science des ingénieurs* (I); 1731: Rozard, *Nouvelle fortification*; 1735: St. Savain, *Nouvelle école militaire;* 1738: Naudin, *L'ingénieur français*; 1739-86: Le Blond, *Eléments de fortification*; 1741: Cormontaigne, *Architecture militaire;* 1742: Deidier, *Le parfait ingénieur*; 1742: Montesson, *Fortification rég. et irreg.;* 1749-57: Clairac, *L'ingénieur de campagne;* 1757-62 : de Bonneville, *Fortification* (UK); 1768-78: Fallois, *L'école de la fortification* (D); 1769: Cugnot, *La fortification de campagne;* 1776-84: Montalembert, *La fortification perpendiculaire;* 1793: Montalembert, *L'art défensive supérieure;* 1795-1815: Briche, *L'ingénieur républicain* (P).
Spain	1700-35: Fernandez de Medrano, *El arquitecto perfecto en el arte militar*; 1708-23: Fernandez de Medrano, *El perfecto artificial, bombardero, artillero*; 1767: Plo y Comin, *El arquitecto prático civil, militar e agrimensor*; 1772: Lucaze, *Principios de fortificacion*.

	Military treatises and their periods of circulation
Portugal	1713: Vale, *Fortificaçam moderna*; 1728: Fortes, *O Engenheiro Português*; 1744: Alpoym, *Exame de artilheiros*; 1796: Azedo, *Compendio Militar.*
The Netherlands	1702-41: Coehoorn, *Nieuwe vestingbouw* (D) (F) (UK); 1710-61: Sturm, *Le veritable Vauban* (F).
Great Britain	1707: Barker, *The treasury of fortification*; 1742-71: Robins, *New principles of gunnery* (D) (F); 1746-1807: Muller, *A treatise containing the elementary part of fortification* (E); 1768-94: Pleydell, *An essay on field fortification*; 1780: Lochée, *Elements of fortification*; 1787: Horst, *Remarks on a new system of fort* (F).
Germany	1703-14: Borgsdorff, *Neutriumphiende fortification*; 1711-16: Decker, *Forstlicher baumeister*; 1720-49: Bodenehr, *Fortification wegen berühmteste staette*; 1728: Herrmann, *La fortification* (F); 1760-70: Brühl, *Ecole de l'officier* (F); 1780-89: Tielke, *Unterricht für die Officiers* (UK).

Fort Tigné, designed by the French engineer, Tousard, and built in a record time of just two years (1792-94), was based on the most recent fortification thesis by Montalembert. It was set out in a diamond shape with a bombproof cylindrical tower on the angle facing the mouth harbour and featured a counterscarp and three levels of galleries for muskets fire as well.

In 1798, with the arrival of the troops sent by the "Directoire" and commanded by General Vaubois, the majority of Malta's fortifications was already finished and was not used to withstand an enemy no one had anticipated during the previous three centuries. This event meant the end of a unique historical period marked by the constant enhancement of the Maltese defensive systems.

Given the presence of the Knights, Malta constituted a true Bastion of the European continent, able to offer strong resistance to the advance of Ottoman power in Western Europe. Over the period discussed, the Maltese fortifications exemplify the most advanced theories for defence, theories developed in response to military capabilities and the inventiveness of Ottoman offensive strategies. To understand the training context of the protagonists of this construction *saga* and the body of texts which divulged this knowledge permits the recognition of the true legacy left by Maltese military architecture, a common heritage belonging to the whole of Europe.

ABBREVIATIONS

D - German; B - Flemish/Belgian; E - Spanish; F - French; I - Italian; L - Latin;
M - Maltese; NL - Dutch; P - Portuguese; SE - Swedish; T - Turkish; UK - English.

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