Military Engineering in the Ottoman Empire

> "The Ottoman Turks may be called the Romans of the Muslim world. They imposed a definitive order upon what had developed earlier: a bureaucracy, a legal system, and Sunni Islam itself, with its balance between two ways of looking at religion, as a system of ideal social behavior and as a path towards experiential knowledge of God."[1]

The military engineering in the Ottoman Empire in early modern era was performed by the artisans, craftsmen, architects, and engineers in various fields of expertise such as production of firearms and ammunition, construction of fortifications, building of warships. Military acculturation in the Mediterranean and the Danubian basins were crucial in the flourishing of Ottoman military engineers who transmitted innovations to their eastern allies and rivals.

An overview of historiography

Developments in firearms technology in early modern age came in two waves of technological innovation in early modern Europe. The first wave was directly linked to the invention of corned powder in the early fifteenth century and drew the limits of the subsequent technological developments until well into the 19th century. By the 1530s the standard cannon was a single-piece bronze-cast muzzleloader firing an iron cannonball with a charge of corned gunpowder amounting to about one-half the shot's weight. In the following three centuries little was changed in the design of the cannon. Largely characterized by the refinement of the existing technology, the second wave of innovations succeeded in replacing the matchlock with the flintlock muskets, standardizing the caliber, carriages and the equipment of the artillery that became more

[1] Albert Hourani, "How Should We Write the History of the Middle East?", *International Journal of Middle East Studies* 23/2 (1991), p. 130.

manoeuvrable due its light weight, and finally in achieving mass production of arms particularly during the Napoleonic Wars.[2]

Under the impression of contemporaneous foreign observers, 'the Sublime Porte' has been considered as a gunpowder empire that owed its political and military successes to foreign experts of Western origin that introduced the secrets of firepower weaponry to the Ottomans throughout the early modern age. Destined to remain as an imitator, the argument follows, the Ottomans steadily lagged behind vis-à-vis their Western rivals. One historian has summarized the Eurocentric and Orientalist misconceptions about Ottoman military technology under the rubrics of "(1) Islamic conservatism; (2) the East-West technological divergence; (3) Ottoman technological inferiority and backwardness; (4) insufficient production capacity and Ottoman dependence on European know-how and imports."[3] In a nutshell, the Ottomans were believed to manufacture giant guns when their Western rivals opted for light field artillery; the Ottoman military failed to incorporate the new infantry tactics (volley fire) and siege tactics to its existing body; and finally, the empire suffered from metallurgical inferiority and depended on European imports of arms as well as raw material throughout the early modern period.[4]

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[2] Bert S. Hall, *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology, and Tactics* (Baltimore: The John Hopkins Uni. Press, 1997), pp. 87-94; Keith Krause, *Arms and the State: Patterns of Military Production And Trade* (Cambridge: Cambridge University Press, 1992), pp. 9-12, 54-6.

[3] Gábor Ágoston, "Disjointed Historiography and Islamic Military Technology: The European Military Revolution Debate and the Ottomans", in M. Kaçar and Z. Durukal, (eds.), *Essays in honour of Ekmeleddin İhsanoğlu*, vol. I: "Societies, cultures, sciences: a collection of articles" (İstanbul: IRCICA, 2006), p. 572.

[4] This literature is best exemplified by the following works among many others: M. Carlo Cipolla. *Guns, Sails and Empires: Technological Innovation and the Early Phases of European Expansion 1400-1700* (London: Collins, 1965); Geoffrey Parker. *The Military Revolution: Military Innovation and the Rise of the West 1500-1800* (Cambridge: Cambridge University Press, 1988; revised edition 1999) [Parker revised some of his views on Ottoman technological incompetence taking account of Ágoston's findings.]; Paul Kennedy, *The Rise and Fall of the Great Powers: Economic Change and Military Conflict from 1500 to 2000* (New York, 1989). Ágoston has challenged this literature on many occasions. See his *Guns for the Sultan: Military Power and the Weapons Industry in the Ottoman Empire* (Cambridge: Cambridge University Press, 2005), pp. 3-8.

Since the 1980s, researchers of Ottoman science and technology have made genuine attempts to correct such easy generalizations and presumptions about the 'backwardness' and 'technological inferiority' of the Ottoman Empire. Recent studies have shown that the Ottoman corned powder had the same qualities as its European counterparts in terms of the proportions of its saltpeter, sulphur, and charcoal ingredients. Apparently, the output of gunpowder works at various locations had different properties which led several eyewitness accounts to contradict each other on the quality of the Ottoman gunpowder.[5] Furthermore, theories about Ottoman giant guns proved to be misguided as the archival evidence showed that most of the output of the Ottoman foundries throughout the early modern period was composed of light guns. For instance, 97% of 1,027 guns produced in the four years preceding the battle of Mohács (1526) consisted of small and medium sized guns.[6]

In refutation of Eurocentric and Orientalist views, Murphey sought economic explanations for the perceived decline of Ottoman war industries, which he dated to the late seventeenth century. What accounted for the Ottoman failure to keep in pace with Europe was natural shortages in raw materials and the mercantilist policies of its rivals which imposed restrictions on the flow of information as well as the basic materials essential to Ottoman industry. Negative impacts of these structural changes were not restricted to military technology, but also affected sectors such as clock-making by the

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[5] Ágoston, "Gunpowder for the Sultan's Army: New Sources on the Supply of Gunpowder in the Hungarian Campaigns of the Sixteenth and Seventeenth Centuries", *Turcica* XXV (1993): 75-96 and his *Guns for the Sultan*, pp. 155-58. See tables 1-13 in the Appendix, pp. 208-14.

[6] Ágoston, *Guns for the Sultan*, pp. 184-89. Especially, Table 6.6 (p. 186) and tables 14 through 69 in the Appendix (pp. 215-41); for similar conclusions see Kahraman Şakul, "General observations on the Ottoman military industry, 1774-1839: Problems of organization and standardization in arms production" in F. Günergun, S. Kuriyama, D. Raina (ed.), *Adoption and Adaptation - The travel of methods, techniques and technologies between Asia and Europe and the transformations of know-how* (Springer, forthcoming); Ágoston, "Ottoman Artillery and European Military Technology in the 15th to 17th Centuries" *Acta Orientalia Academiae Scientiarum Hungaricae* 47 (1994), p. 43.

1680s and, in the long run, resulted in the peripheralization and gradual incorporation of the empire into the world system.[7] Ágoston, on the other hand, pointed out Ottoman imports of war materials remained in negligible quantities until the 18th century. The Ottomans were self-sufficient in raw materials needed for the firepower weaponry except for tin. Supply shortages were not caused by the lack of raw materials or the decline of English and Dutch imports but were rather inevitable consequences of double-front engagements such as the Long War (1594-1606) and the War with the Holy League (1683-1699). Such engagements hindered the transportation of weapons and ammunitions to war zones in time from the production plants scattered all over the empire.[8]

At present, there is a consensus among the Ottomanists that the real problem was not so much technological backwardness or lack of receptivity to new ideas but institutional incompatibility which reached at a critical point in the period after the Seven Years War. Relevant researches contextualize science and technology within the Ottoman world and argue for what we may call the Ottoman culture of transfer of technology. Accordingly, military acculturation in Ottoman context was a highly selective process throughout the early modern era. Well-known Ottoman pragmatism and flexibility were also at work in adoption and adaptation of military arts and sciences. While the Ottomans developed a pragmatic interest in various developments in military technology in Europe, they were flexible enough to harmonize them with their own traditions and existing

[7] Rhoads Murphey, "The Ottoman Attitude Towards the Adoption of Western Technology: The Role of the Efrenci Technicians in Civil and Military Applications", in J. L. Bacqué-Grammont & P. Dumont (eds.), *Contributions a a l'histoire economique et Sociale de l'Lempire Ottoman*, (Paris, 1983), pp. 288-301.
[8] Ágoston, "Merces prohibitae: The Anglo-Ottoman Trade in War Materials and the Dependence Theory", *Oriente Moderno* [Kate Fleet ed., The Ottomans and the Sea] XX (LXXXI) n.s. 1 (2001): 177-192; Ágoston, "Habsburgs and Ottomans", p. 139.

institutions, thus shaping an Ottoman culture of transfer of technology which has yet to be appreciated.[9]

Fertile grounds for military acculturation: the Danubian and the Mediterranean basins

The Ottomans had acquired their first firearms in the 1380s through the Balkans while China and the Middle East should not be ruled out as a potential transmitter of the gunpowder technology. Venetian-Hungarian rivalry over the control of the Dalmatian coast made Italy the main supplier of firearms of the Balkan countries. By the 1360s, Ragusa/Dubrovnik, which was the main port for the imported Italian cannon, was already manufacturing small firearms. Countless papal bans on the export of war materials to the Balkans only attested to the intensity of the prohibited trade.[10] Besides Ragusa, the Serbian contingents could have introduced firearms to their suzerains when serving in the Ottoman army against the Karamanids in Anatolia (1386).[11]

The earliest information upon gun making in the Ottomans is dated back to the siege of Hexamilion (*Germehisar*) in the Peloponnese in 1438 when cannons were made in a mobile arsenal founded nearby. The Ottomans usually cast their siege guns on the site in the fifteenth century since the carriages with axle system were unknown then. Notably, mobile foundries were not yet in use in most of Europe at that time. The first Ottoman arsenal was founded in Edirne in the reign of Murad II. After the conquest of

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[9] Ekmeleddin İhsanoğlu, "Ottomans and European Science", in William K. Storey (ed.), *Scientific Aspects of European Expansion* (Hampshire, 1996): 315-26; İhsanoğlu, "Ottoman Science in the Classical Period and Early Contacts with European Science and Technology", in İhsanoğlu (ed.), *Transfer of Modern Science & Technology to the Muslim World* (İstanbul: IRCICA, 1992): 1-48; Ágoston, *Guns for the Sultan*, pp. 15-61; İhsanoğlu, A. Djebbar and F. Günergun (eds.), *Proceedings of the International Congress of History of Science (Liège, 20-26 July 1997) volume VI, Science, Technology and Industry in the Ottoman World* (Turnhour: Brepols Publisher, 2000).

[10] D. Petrovic, "Fire-arms in the Balkans on the Eve of and After the Ottoman Conquest of the 14th and 15th Centuries", in Parry and Yapp (eds.), *War, Technology and Society in the Middle East* (London: Oxford University Press, 1975), pp. 169-87; Ágoston, *Guns for the Sultan*, pp. 16-21.

[11] İnalcık, "David Ayalon'un *Gunpowder anf Firearms in the Mamluk Kingdom* adlı eserinin tanıtım yazısı", *Belleten* 83 (1957), p. 509; Ágoston, "Ottoman Artillery", pp. 22-3.

Constantinople, *Tophane-i Amire* (the Imperial Gun Foundry) was built where most of the enterprise was run until the end of the period under discussion.[12]

The *Tophane* was one of the earliest examples of an arsenal that was built, operated and financed by a central government. While cannon production was contracted out to the private sector in most of the European states, powder mills and arsenals in the Ottoman Empire were in the possession of the state. As was the case in mining and shipbuilding, free craftsmen, slave labour, and forced labour mobilized from the countryside for a six-month period were utilized in the foundry under the supervision of the contractor appointed by the state. This system made it possible to cast cannon in abundant quantities. Besides the imperial foundry, there were also minor arsenals at the strategically important centres on the campaign routes.[13]

Major innovations in military technology took place in certain areas in Europe such as the Low Countries and England. According to one view transmission of inventions in military technology and engineering came in waves that consisted of rapid innovation and its diffusion from the first-tier innovators to second-tier exporters to third-tier imitators. The Ottoman Empire is depicted in this model as a third-tier state that sought to create an indigenous arms industry through technological imports without capturing the underlying process of innovation or adaptation.[14] The logical conclusion of this argument held that the Ottoman Empire could not have declined in terms of military

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[12] Salim Aydüz, *Tophane-i Amire ve Top Döküm Teknolojisi* (Ankara: TTK, 2006), pp. 43-9, 74-86; İnalcık, "David Ayalon'un", p. 509; Ágoston, "Ottoman Artillery", p. 26.

[13] Ágoston , "Early Modern Ottoman and European gunpowder technology", in E. İhsanoğlu, K. Chatzis, E. Nicolaidis (eds.), *Multicultural Science in the Ottoman Empire* (Turnhout: Brepols, 2003), p. 17; "Aydüz, *Tophane-i Amire*, pp. 49-74, 479; Colin Heywood, "The Activites of the State Cannon-Foundry (Tophane-i Amire) At İstanbul in the Early Sixteenth Century According to An Unpublished Turkish Source", *Prilozi za Orijentalni Filologiju* 30 (1980): 209-17.

[14] Krause, *Arms and the State*, pp. 9-12.

technology but had occasional setbacks at best in transfer of technology since it had always remained as a third-tier state in 1500-1800. Moreover, the Sublime Porte should be considered as a regional power and thereby compared with its immediate rivals -the Balkan states, Hungary, Poland, and Russia in the West, and Egypt and Iran in the East.[15]

Developed for the post-1945 global arms transfer system, this model does not accommodate the realities of the early modern age in which many second-tier states such as Venice ceased to exist whereas the Ottoman Empire did not. Ágoston's works on Ottoman war-industry plants in sixteenth-seventeenth centuries vitiated the relegation of the Ottomans to the status of a third-tier state. Besides, firearms and innovations diffused from one 'third-tier producer' to another on the global level. The model, nevertheless, rightly stresses the role of geopolitics in military acculturation and aroused the interest of various historians with different regional specializations.[16]

The Balkans and the Mediterranean basin were of crucial geopolitical importance for the Ottomans and they shaped the way in which the Ottoman culture of technology evolved throughout the ages. These two regions served as a pool of experts for many states including the Ottoman Empire as exemplified in the well-known story of the gunmaster Orban, whom had offered his service to the Byzantine Emperor before hired by the Ottoman sultan Mehmed II (the Conqueror). Nevertheless, the role of such foreign

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[15]Jonathan Grant, "Rethinking the Ottoman "Decline": Military Technology Diffusion in the Ottoman Empire, Fifteenth to Eighteenth Centuries", *Journal of World History* 10 (1999): 179-201; Grant did not cite Ágoston's studies. For his evaluation see, Ágoston, "Behind the Turkish War Machine: Gunpowder, Technology and Munitions Industry in the Ottoman Empire, 1450-1700", in B. Steele and T. Dorland (eds.), *The Heirs of Archimedes: Science and the Art of War through the Age of Enlightenment* (Cambridge, MA: MIT, 2002).

[16] Krause, *Arms and the State*, p. 33; Thomas Allsen, "The Circulation of Military Technology in the Mongolian Empire", in N. Di Cosmo (ed.), *Warfare in Inner Asian History (500-1800)* (Leiden: Brill, 2002), pp. 284-85; Manchus actually acquired the European firepower technology from the Ming –both states being third-tier producers, see N. Di Cosmo, Nicola Di Cosmo, "Did Guns Matter? Firearms and the Qing Formation", in Lynn Struve (ed.), *The Qing Formation in World-Historical Time* (Cambridge, Mass.: Harvard University Press), p. 160-61. This is also true for the case of the Sa'dian sultanate, see footnote 22.

experts in Ottoman military has been largely exaggerated –most of the casters were actually Muslim. There was no one-way traffic in the west-east direction in the transmission of new methods and techniques as well as arms. It should be noted that, none of the European states could supply itself within its own borders as a result of the expansion of armies. Europe could not produce enough saltpetre for its own consumption and particularly the English and Dutch imports of saltpetre from India increased throughout the seventeenth century. Moreover, Britain, Netherlands and France depended on the timber supply of the Baltic regions. Qualified personnel in the technology of fire-arms were in scarcity in the Balkans and the Ottoman territories, as was the case in Europe so much so that even the first-tier and second-tier states such as England and Sweden had to rely on foreign expertise. Ottomans recruited in the conquered territories the competent Christian smiths, stone carvers, carpenters, masons, caulkers and ship-builders besides war captives and adventurers. The Slav mine-workers in the Balkans played a crucial role in the transfer of the Western technology of ore mining to the Ottomans in the 15th century. Saxon technology was employed in these mines thanks to Saxon miners settled there in previous centuries and the Ottomans continued with the established Saxon mining laws after the conquest by granting these miners share on the profits so as to maximise the amount of output.[17]

Throughout the early modern period, Istanbul was an international hub in the transmission of military technology in all directions. For instance, a certain cannon founder by the name of George experimented with a prototype of reverberatory furnace

[17] Ágoston, "Ottoman Artillery", pp. 26-7; Ágoston, *Guns for the Sultan*, pp. 44-7; Petrovic, p. 192; İnalcık, "David Ayalon'un", p. 509

in Frankfurt in 1486 –a technique which he was likely to have learned during his long-term service in the İstanbul foundry.[18]

The case of the Papa garrison in Hungary constituted a particular case which attested to the importance of war in breeding military acculturation. The French and Walloon mercenaries of the garrison decided to defect to the Ottoman side in the Ottoman-Habsburg War (1593-1606) when their pay fell in arrears. The Ottomans benefitted many years from the services rendered by this group of roughly 700 well-equipped men with up-to-date knowledge of firepower tactics. Relevant Ottoman registers referred to them as a unique group of foreign technicians and labelled them as 'the corps of Franks' (*taife-i Efrenciyan*). While little is known on this specific corps, its members seem to have served in the capacity of military advisers in siege warfare, musketeers and gun-casters on many occasions.[19]

Ottoman adoption of wagenburg in the 15th century provides another interesting case that sheds light on the central role of the Danubian warfare in the diffusion of firepower tactics. First used by the troops of Jan Huss in Bohemia during the Hussite wars (1419-1436), the wagenburg was arranged by chaining trains of heavily armed wagons to one another in a circular shape. Hungarians decided to employ the tactic in order to repulse the dreaded Ottoman cavalry in the 1440s. The Ottomans were so impressed that they readily adopted the *tabur* –after the Hungarian szekertabor- after the

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[18] Ágoston claims that George could be the same Jörg of Nuremberg who wrote *Ein Tractat von der Türcken*, see Ágoston, *Guns for the Sultan*, pp. 48, 194, fn. 6; Aydüz, "Artillery Trade in the Ottoman Empire", publication ID: 610, July 2006, FSCT limited, p. 12, accessible at www.muslimheritage.com.

[19] Murphey, "The Ottoman Attitude", pp. 288-97; the corps was composed of 44 men (1613-1629), 25 men (1634-35), 4 men (1639-42), 1 man (1657-1670), see Aydüz, "XIV.-XV. Asırlarda, Avrupa Ateşli Silah Teknolojisinin Osmanlılara Aktarılmasında Rol Oynayan Avrupalı Teknisyenler (Taife-i Efrenciyan)", *Belleten* LXII/235 (1998), pp. 828-30; Caroline Finkel, "French Mercenaries in the Habsburg-Ottoman War of 1593-1606: The Desertion of the Papa Garrison to the Ottomans in 1600", *Bulletin of the School of Oriental and African Studies, University of London* 55/3 (1992), p. 468.

pitched-battle of Varna (1444). Similar Turco-Mongolian defensive tactics and this partly explains the relative ease with which the Ottomans adapted to the new tactic although incorporation of fire-arms was a novelty.[20]

Ottomans were responsible for the introduction of *tabur cengi* (wagenburg/camp battle) to the East. Many Ottoman experts and adventurers taught the Safavids –the arch-enemy of the Ottomans- and the Mughals the wagenburg which was known in the East as 'the Roman/Ottoman norm' (*düstur-i Rumi*). The Safavid Shah Tahmasb routed the Uzbeks in 1528 owing to the new tactic while the Uzbeks requested at once from İstanbul fire-arms and specialists in order to employ the wagenburg. Babür, the Mughal Sultan, recruited some Ottoman adventurers who were experts in making of fire-arms and using them in the midst of the sixteenth century. Among several Muslim countries that received firepower tactics and technology were the Khanates in Türkistan, Mamluks of Egypt, Abyssinia, Gujerat (India), and Acheh (Sumatra/Indonesia). Ottoman military support partly contained the Portuguese threat as revealed in the defence of Diu (western India).[21] According to Parker, "an early transmission of the Military Revolution of early modern Europe to a Muslim society occurred in Sa'dian Morocco towards the mid-16th century when the Moroccans learnt using artillery weapons and siegecraft thanks to renegades and Turks."[22]

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[20] H. İnalcık and Oğuz (eds.), *Gazavat-ı Sultan Murad b. Mehemmed Han* (Ankara: TTK, 1989), pp. 92-3; İnalcık, "David Ayalon'un", pp. 506-10.

[21] İnalcık, "The Socio-Political Effects of the Diffusion of Fire-arms in the Middle East", in Parry and Yapp (eds.), pp. 195-207; Salih Özbaran, "The Ottomans' Role in the Diffusion of Fire-arms and Military Technology in Asia and Africa in the Sixteenth Century", in Özbaran (ed.), *The Ottoman Response to European Expansion* (İstanbul: Isis, 1994), pp. 61-6; Ágoston, *Guns for the Sultan*, pp. 18-19; R. Reid, "Sixteenth-century Turkish Influence in Western Indonesia", *Journal of Southeast Asian History* 10/3 (1969): 395-414; Giancarlo Casale, *The Ottoman Age of Exploration* (Oxford, New York: Oxford University Press, 2010) has been released too late to consult in this study.

[22] G. Parker, "The artillery fortress as an engine of European overseas expansion, 1480-1750", in James D. Tracy, *City Walls: The Urban Enceinte in Global Perspective* (Cambridge: Cambridge University Press,

Sources suggest that the earliest muskets in China may have been of Ottoman origin and Chinese military strategists developed a particular interest in studying and emulating Ottoman muskets by the end of the 16th century. A five-volume Chinese military treatise (*Shen Qi Pu*) written in reaction to the Japanese expansionism in Korea compared the Ottoman musket favourably with its European and Japanese counterparts. The author (Chao Shi Zhen) augmented his argument by manufacturing a musket modelled on the Ottoman musket.[23] Apparently, Ottoman muskets shot larger bullets, had a longer range with more penetrating power vis-à-vis the European muskets since their barrels were made of flat sheets of steel that were to be coiled into a spiral. This was the traditional metalworking technique applied in the production of the Damascus blade.[24] There are references that as early as 1513 the Muslim principalities of Hami and Turfan had used Ottoman muskets while the renowned battle wagons of the Ming general Qi Jiguang who defeated the Mongols quite resembled the wagenburg.[25]

The formidable volley fire, which has been regarded as one of the fundamental aspects of the military revolution in Europe, presents an intriguing case that suggests that there did not necessarily have to be a single core area from which all innovations must have diffused in succeeding waves. The Japanese employment of volley fire in the battle of Nagashino in 1575 preceded the invention of the Dutch volley fire by at least 30 years.

2000), pp. 406-7. In 1578, the Sa'dian army defeated the Portuguese in the battle of Alcazaquiver and later conquered the sub-Saharan Songhay empire in 1590-1. This is another case of diffusion of military innovation from a 'third-tier producer' (the Ottomans) to another 'third-tier state' in Krause's model.

[23] Di Cosmo, "Did Guns Matter?", p. 133; Kazuaki Sawai, "XVI. Yüzyılda Doğu Asya'da Osmanlı Tüfeğinin Yeri", in F. Emecen (ed.), *Eskiçağ'dan Modern Çağ'a Ordular –Oluşum, Teşkilat ve İşlev-* (İstanbul: Kitapevi, 2008), pp. 341-54.

[24] Ágoston, *Guns for the Sultan*, pp. 48, 91, 193; According to Chao Shi Zhen the Ottoman musket weighed 4.18-4.78 kg and was 1.87-2.18 m-long, shooting a bullet of 18 g. A lighter type, however, weighed 3.58 kg and shot a projectile of 12 g, Sawai, "XVI. Yüzyılda Doğu Asya'da Osmanlı Tüfeğinin Yeri", pp. 346-47; Ágoston's data from the mid-16th century agree with the data on the lighter type, Ágoston, *Guns for the Sultan*, pp. 90-91; also see, Murphey, *Ottoman Warfare 1500-1700* (New Brunswick, Rutgers University Press, 1999), pp. 105-111 and his "The Ottoman Attitude", p. 291.

[25] Di Cosmo, "Did Guns Matter?", pp. 124, 132.

In the same vein, the Ottomans may have developed the volley fire by themselves as argued by Börekçi elaborately. There is strong visual and written evidence that suggest that the Ottoman Janissaries were likely to use the volley fire in the pitched-battle of Mohács in 1526 while there is no doubt that they practiced it in 1597 and 1605.[26]

Nevertheless, both the Ottoman and the Japanese volley fires fell short of causing large-scale transformations as it did in the West. While musket fell in disuse in Japan in the following centuries, the nature of warfare in Hungary favoured siege warfare over pitched-battles; as Ágoston has pointed out only two important pitched-battles were fought between 1526 and 1683 in Hungary (Mezokeresztes in 1596 and Szengotthard in 1644). Warfare in Hungary was largely dominated by protracted sieges and continuous skirmishes on the frontier. Thus siege artillery tactics were more advanced than the field artillery tactics in Ottoman military whereas considerable numbers of cavalry forces were necessary for the skirmishes. The scorch-and-earth tactics of Safavids equally discouraged pitched-battles in the East and necessitated the availability of cavalry in substantial numbers. Structural changes occurred, however, by the end of the 17th century. The Ottomans had to fight 15 battles in 1683-97 with the Habsburgs and lost most of them since the latter had undergone a thorough transformation in the size and

[26] Günhan Börekçi, "A Contribution to the Military Revolution Debate: The Janissaries Use of Volley Fire during the Long Ottoman-Habsburg War of 1593-1606 and the Problem of Origins", *Acta Orientalia Academiae Scientiarum Hungaricae* 59/4 (2006): 407-438 [DOI: 10.1556/AOrient.59.2006.4.2]; for a positive evaluation of Börekçi's arguments see Geoffrey Parker, "The Limits to Revolutions in Military Affairs: Maurice of Nassau, the Battle of Nieuwpoort (1600), and the Legacy", *The Journal of Military History* 71 (2007): 331-72. Parker suggests that afore-mentioned French mercenaries might have taught the Janissaries the volley fire and overlooks the evidence regarding the Mohács, see esp. pp. 358; Ágoston also remarks that at Mohács, the Janissaries were deployed in nine consecutive rows, each row firing in succession, Ágoston, *Guns for the Sultan*, p. 24.

composition of the military forces as well as in logistics and supply system owing to a number of administrative and fiscal reforms.[27]

Fortifications

Art of fortification both required theoretical learning particularly in geometry and a great deal of practice. Learning institutions fell within the orbit of the Ottoman centralization and bureaucratization that Hourani drew attention to in the quotation of the beginning of this article. This highly sophisticated system embodied many *medrese*s offering education on various levels ranging from secondary schools to universities.[28] The novices in the fields of engineering and architecture underwent a vigorous theoretical and practical training in several palace and army corps of architects, artisans and craftsmen such as those of wagon-makers, miners and sappers.[29]

In the age of expansion (1453-1699), the Ottoman military engineers acquainted themselves with various styles of architecture and techniques existing in different parts of the empire. The career of the celebrated Ottoman architect *Mimar* (architect) Sinan Ağa is illustrative. Born in the town of Kayseri to a Christian family, the young Sinan was recruited into the Janissary army. After completing his formal training in geometry, surveying techniques, and construction methods, he was put in the command of the 82nd regiment of the Janissary army in charge of catapults and mechanical devices for many

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[27] Ágoston, "Ottoman Artillery", p. 48.

[28] Arithmetic, geometry and astronomy were not treated as individual course topics in the *medrese* curricula but they were taught in other courses such as physics. Arithmetic was also offered in various convents privately. Italian priest Abbé Toderini observed in the 1780s that 'the Turks' would astonish the best European mathematicians with their quickness in solving out the most complicated problems. French technicians Monnier and De Lafitte Clavé confirmed that some 'Turks' were studying on geometry books in European languages, see C. İzgi, "Osmanlı Medreselerinde Aritmetik ve Cebir Eğitimi ve Okutulan Kitaplar", *Osmanlı Bilimi Araştırmaları* I, E. İhsanoğlu, "Ottoman Educational and Scholarly-Scientific Institutions", in İhsanoğlu (ed.), *History of The Ottoman State, Society & Civilisation* (İstanbul: Ircica, 2002), vol. 2, pp. 361-512.

[29] Gülru Necipoğlu, *The Age of Sinan. Architectural Culture in the Ottoman Empire* (London: Reaktion Books Ltd, 2005), pp. 153-88.

years. The level of experience and competence an Ottoman military engineer would attain in that age could be inferred by his life story. He constructed warships and even commanded them in Lake Van during the 1534-37 Bagdad campaign just a couple of years before he was commissioned with setting up a bridge on the river of Pruth on marshy land during the Moldavian campaign. By the year of 1539 he was appointed as the chief of the Corps of the Royal Architects that gradually evolved into an empire-wide network under his supervision until his death in 1588. Patronage for ambitious architectural projects was such that the Corps ultimately achieved a degree of standardization in the dimensions of timber pillars and beams, wooden planks and shingle roofs in order to cope with the pending orders. Standardization was also reached in architectural taste owing to Sinan's legacy in the profession that disseminated throughout the empire in his term of office.[30]

Sinan was revered by the contemporaries as the 'Great Architect' and 'Chief of the World's Engineers' and he could attend imperial council meetings in his capacity as the chief architect. In the 16th-17th centuries there were roughly 40 architects in the corps and all major provinces such as Bosnia, Erzurum, Diyarbakir, Van, Buda and many others had their own chief architects appointed from among the Royal Corps who were put in charge of military projects. Besides, the Chief Architect of the Royal Corps also appointed the city architects who would serve under the judge (*kadi*) in order to ensure that the official buildings would be kept in good shape and no new building would be constructed without their approval.[31]

[30] Necipoğlu, *Age of Sinan*, pp. 132-34, 158.
[31] Necipoğlu, *Age of Sinan*, pp. 154-58, 165-66.

This was the age when the Ottoman strategists entertained engineering projects that would be found ambitious even by the standards of the succeeding centuries. Among these should be counted the projects concerning the digging of Suez, Don-Volga, and Sakarya-İzmit canals in the mid-16th century. While the first project was conceived as a measure against the Portuguese, the second project aimed at linking the Black Sea with the Caspian Sea. This would have enabled the Ottomans to maintain a navy to check the Muscovite expansion in north Caucasus and the Safavids. The Sakarya-İzmit canal would have connected the Black Sea and the Marmara and served as a waterway to bring timber and firewood to İstanbul for the need of the navy and of various construction sectors. Another project of a lesser scale was the construction of a water channel from Jiddah to Mecca which was the last will of Süleyman the Lawgiver (Magnificent). While none of these projects came into fruition, they were not rejected out of hand as unrealistic dreams of some engineers either. In the last case 30 architects were indeed sent to the spot in 1573 but Sultan Selim II opted for the cheaper solution of digging wells at regular intervals along the route to Mecca. As for the Sakarya-İzmit canal, Sinan actually surveyed the region of Lake Sapanca and Bay of İzmit. In the case of Don-Volga canal, the Ottomans partly dug the canal in 1569 only to abandon the project due to the inhospitality of the steppe, harassment of the Muscovites, and unsupportive Tatar allies. While these projects were re-considered from time to time, funds required for the task had to be diverted to more pressing needs of the empire.[32]

[32] Ágoston, "Where Environmental and Frontier Studies Meet: Rivers, Forests, Marshes and Forts along the Ottoman-Hapsburg Frontier in Hungary", in A. Peacock (ed.), *The Frontiers of the Ottoman World* (New York: Oxford University Press, 2009), pp. 57-79; Akdes N. Kurat, "The Turkish Expedition to Astrakhan in 1569 and the Problem of the Don-Volga Canal", *Slavonic and East European Review* 40 (1961): 7-23; İnalcık, "The Origins of the Ottoman-Russian Rivalry and the Don-Volga Canal", *Annales de l'Université d'Ankara* 1 (1947): 47-110; G. Necipoğlu, *The Age of Sinan*, pp. 141, 160.

Major challenge for the proper understanding of Ottoman architecture and engineering is the lack of a theoretical literature that discusses different aspects of the profession. The guild structure discouraged the practisers to share their professional secrets with the general public through penning treatises. Moreover, centralization of architectural projects under the head of the Corps of the Royal Architects condemned most of the architects to remain in oblivion. The situation is further exacerbated by the survival of only a fraction of Ottoman drawings and models of various undertakings.[33] However, the surviving drawings do not much differ from those existed in Europe in terms of technicality and sophistication.[34]

Foreign observers of Ottoman fortresses whom were usually subjects of the rival states such as Montecuccoli held negative views about the Ottoman military architecture and these views have resonated in most of the modern studies on the subject. The most common criticism has been about the Ottoman preference of rounded bastions, conical roofed, tall, and multi-tiered gun towers as opposed to star-shaped, pointed bastions, namely, *trace italienne*. There is a common consensus that most of the Ottoman fortresses were actually captured from the Christian rivals and the Sublime Porte neglected their upkeep and maintenance.[35] Nevertheless, both voluminous archival records on regular fortress renovations and the breakdown of various Ottoman budgets call such assumptions in question. Besides, new studies suggest that Ottomans did not

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[33] Lucienne Thys-Şenocak, *Ottoman Women Builders: The Architectural Patronage of Hadice Turhan Sultan* (Hampshire, Burlington: Ashgate, 2006), p. 162; Necipoğlu, *Age of Sinan*, p. 171.

[34] Ottoman architects and engineers used papers with standardized grids in exact measures and made drawings and three-dimensional models (made of wood and of bronze), see Thys-Şenocak, *Ottoman Women Builders*, pp. 163-66; for some examples of the surviving drawings see Necipoğlu, *Age of Sinan*, pp. 171-72, Burcu Özgüven, *Osmanlı Macaristanı'nda Kentler, Kaleler* (İstanbul: Efe, 2001), p. 61and C. Finkel and Victor Ostapchuk, "The Archeology and Construction History of the Black Sea Fortress of Özi", *Muqarnas* 22 (2005), p. 164 .

[35] K. Andrews, *Castles of the Morea* (NJ: Princeton, 1953), p. 231; Simon Pepper, "Ottoman military architecture in the early gunpowder era: A Reassessment", in Tracy (ed.), pp. 282-316.

exclusively follow the medieval fortress design. While it was sometimes a matter of urgency and expediency to adopt conservative designs as was the case in the fortification of the Dardanelles in the mid-17th century against the Venetian threat, at other times it was imposed by financial or geographical constraints –the nature of warfare notwithstanding.[36]

Most of the artillery-resistant fortresses in Europe were simply the renovated medieval fortresses. Apparently, China never upgraded its fortifications along the new fashion in Europe, but Chinese fortresses withstood the British bombardment in the Opium War on several occasions.[37] It seems a particular type of mortar -*Horasani*- reinforced the supporting pillars of bastions of Ottoman fortresses; brick pieces/powder it contained made it as strong as concrete and rendered the bastions resistant to artillery fire. A peculiar type of castle, *palanqa* (a palisaded structure supported by earth similar to Roman *limes*) perfectly served the needs of the Ottomans in Hungary once the major strong fortresses were taken from the Habsburgs and Hungarians. *Palanka*-type strongholds were also suitable in the Caucasus which was not certainly characterized by strong fortifications.[38]

The Hungarian theatre of war was one of the best fortified regions in Europe despite the assumptions that it had constituted one big undifferentiated open field.[39] This was mainly the consequence of the Habsburg decision to create a new defence system

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[36] Thys-Şenocak, *Ottoman Women Builders*, pp. 172-73.
[37] G. Parker, "The artillery fortress", p. 410.
[38] Mark L. Stein, *Guarding the Frontier: Ottoman Border Forts and Garrisons in Europe* (London: I. B. Tauris, 2007), p. 44; Murphey, *Ottoman Warfare*, pp. 110-16; Özgüven, "*Palanka* Forts and Construction Activity in the Late Ottoman Balkans", in Peacock (ed.), pp. 171-88; Ibolya Gerelyes and Gyongyi Kovacs (eds.), *Archaeology of the Ottoman Period in Hungary* (Budapest: Hungarian National Museum, 2003); Murphey, "The Garrison and its Hinterland in the Ottoman East, 1578-1605", in Peacock (ed.), pp. 353-70.
[39] Geza David and Pal Fodor, "Introduction", in David and Fodor (eds.), *Ottomans, Hungarians, and Habsburgs in Central Europe: The Military Confines in the Era of Ottoman Conquest* (Leiden: Brill, 2000), pp. xi-xxvii; Jozsef Kelenik, "The Military Revolution in Hungary", in the same compilation, pp. 117-59.

along the mountains of Transdanubia after the establishment of Ottoman direct rule in Buda in 1541. Although the construction program was carried out mainly by Italian military engineers along the lines of *trace italienne*, only the fortresses of Gyor (Tr.; *Yanık*, lost to Ottomans in 1594, 1682) and Ersekuyvar (Tr.; Uyvar, lost to Ottomans 1664) were truly of modern design. The fact that only 13 castles in Hungary could resist Ottoman siege for more than 10 days and only 9 for more than 20 days between 1521 and 1566 demonstrates that the Ottomans were quite competent in siege warfare.[40]

The Long War with the Habsburgs (1593-1606), the Baghdad campaigns (the 1620s and1630s), and particularly the protracted siege of Candia [Crete] (1645-69) no doubt helped Ottomans to perfect their siege techniques. The Ottomans used incendiary bombs as early as in the siege of Rhodes (1520) to terrorize the defenders. They readily adopted the grapeshot during the siege of Candia that also witnessed the perfection of parallel trenches and zigzag (approach) trenches; the latter –labelled as 'rat path'- were deeper and longer with curved angles by European standards. While gabions and parapets were among the common features of the siege warfare, the addition of redoubts for the infantry with heavy muskets to parallels was an Ottoman novelty. The Janissary barracks were set up adjacent to the trenches so that the infantry would not leave the trench until the end of the siege which could be as long as a whole year as was the case in the last phase of the siege of Candia (1668). As late as the 17th century the Ottoman sappers and miners had superior skills vis-à-vis their European colleagues since they used to dig in a sitting position rather than on their knees. This made it possible to dig narrower galleries

[40] Ágoston, "Habsburgs and Ottomans: Defense, Military Change and Shifts in Power", in David and Fodor (eds.), pp. 129-32.

with lower ceilings so as to increase the impact of the explosion.[41] The Ottomans influenced Eastern powers in the sphere of siege warfare as well. İskender Muda, Sultan of Acheh, wrested Deli from the Portuguese in 1612 through a rigorous application of parallels and zigzags. The Ottoman engineers also fortified Surat (Gujarat, India) in the 1540s against the Portuguese.[42]

Ottoman navy and ship construction

Naval arsenal of İstanbul and several dockyards of the Empire were principal sites of intense engineering activity. Western observers have considered the Ottoman Empire as a land power and treated the Ottoman navy as a mere logical extension of the idea of holy war, an auxiliary force except for a brief period in the 16th century.[43] The Ottomans began to maintain a regular navy in the 1370s and evolved into what a researcher defined as a 'swimming elephant' by the reign of Süleyman the Lawgiver under the guidance of Barbaros Hayreddin Pasha (Barbarossa). The rise of the Ottomans as a sea-power was due to the conquest of Egypt and the rivalry with the Spanish Habsburgs over the domination of the Mediterranean.[44]

The principal naval arsenal was built on the Genoese old arsenal located on the shore of the Golden Horn until when Gallipoli had served as the major dockyard for the navy. The regular personnel of the naval arsenal were relatively small (90 in 1530, 838 in 1604, 368 in 1648) including those novice Janissaries who had been assigned to the regiments specialized on certain crafts. Most of the work was carried out by prisoners,

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[41] Stein, *Guarding the Frontier*, pp. 29-62; Murphey, *Ottoman Warfare*, pp. 105-32.
[42] Özbaran, "The Ottomans' Role in the Diffusion", p. 66; Parker, "The artillery fortress", p. 396.
[43] Palmira Brummett, "The Ottomans as a World Power: what we don't know about Ottoman sea-power", *Oriento Moderno* [special issue *Ottomans and the Sea*] XX(LXXXI) n.s., no. 1 (2001): 1-21.
[44] Kate Fleet, "Editor's Preface", *Oriento Moderno* [special issue], pp. iii-vi and her "Early Turkish Naval Activities", *Oriente Moderne* [special issue], pp. 129-38; Colin Imber, *The Ottoman Empire, 1300-1650: The Structure of Power* (New York; Palgrave McMillan, 2002), p. 287.

captives, and temporary employees recruited from the provinces for a certain period of time as was the case in the foundry. There were 123 docks with a capacity to construct or maintain 250 galleys at one time by the 17th century. Galley constituted the main fighting force of the Ottoman navy until the 1700s.[45]

While transition from the oared galley to galleon is considered to be the real innovation in the Mediterranean shipping in the early modern era, ship builders –often remained in anonymity in Ottoman case- were rather preoccupied with the improvements made to the design of galley throughout the period. Addition of artillery was the single most modification and the Ottomans followed the suit during the war with Venice (1499-1503). Bronze-cast cannon superseded wrought iron guns in the navy at around the same time. The implementation of *al scaloccio* system by the mid-16th century reduced the dependence on the skilled oarsman and increased the number of the oarsmen by assigning a single oar to each bench. A second mast was added to the standard galley by the end of the century while its stern was rounded and reinforced against tough waves in the 17th century.[46]

Historians have argued that the Ottomans lagged behind their rivals for they failed to adopt sailing galleon fleets at the expense of oar-powered galleys until the end of the 17th century. The transition to galleon in the Mediterranean, however, did not imply technological innovation, but was the outcome of the sharp increase in the volume of merchandise. In fact, middle Mediterranean put the galleon at a disadvantage with its still weather that might last for two weeks during summers. Thus, not only the Ottomans but also Spain and France kept their galley fleets in service even after the armed merchant

[45] Imber, *The Ottoman Empire, 1300-1650*, pp. 292-94.
[46] Imber, *The Ottoman Empire, 1300-1650*, pp. 290-92.

vessels of the Atlantic powers operating in the Mediterranean rendered the galleys worthless as warships.[47] Both the Venetians and the Ottomans had experimented with sailing vessels with high sides in the 15th century but they were rather commissioned for military transportation. The Ottomans were acquainted with the galleasses at the battle of Lepanto (1571) to their dismay and they immediately copied them in a year. The Ottoman attempts to create a fleet of galleons in 1650 once again came as a response to the arch-enemy Venice who effectively blockaded the Dardanelles at one point during the Cretan War. These attempts, however, were defeated by the lack of competent crews and the shipwrights; thus, it was only in 1682 when the galleon became the standard warship in Ottoman navy. While lack of galleons in the 16th century determined the fate of successive Ottoman expeditions in the Indian Ocean, naval warfare in the Mediterranean was characterized by small-scale skirmishes. Huge collisions were less decisive on the sea as proved in Prevesa (1538) and Lepanto. Most of the Ottoman naval expeditions required amphibious operations as in the conquests of Rhodes (1522), Cyprus (1570), Crete, or in the unsuccessful attack on Malta (1565).

Humiliation at Lepanto had a profound impact on Ottoman navy. The Ottomans managed to build and outfit more than 100 warships until the next spring at the expense of transferring the timber planks spared for the renovation of the precinct of the holy Ka'ba (Mecca) to the Naval Arsenal. They nevertheless severely suffered from lack of competent manpower. The new level of realization of the changing nature of naval warfare is evident in the decision to deploy 150 warriors in each galleon (instead of the

[47] John Guilmartin, *Gunpowder and Galleys:Changing Technology and Mediterranean Warfare at Sea in the Sixteenth Century* (Cambridge: Cambridge University Press, 1980).

former figure of 60) –all being required to learn the use of musket.[48] The Ottomans, on the other hand, seem to have coped with the naval innovations with relative ease as suggested by the rapid imitation of galleasses. This was mainly due to the renegades, the Barbary corsairs as well as Christian adventurers and captives who were employed in the naval dockyards. Notably, Mehmed Ağa, a renegade from Livorno, has been credited for the Ottoman acceptance of the galleon as the standard warship in late 17th century who also procured skilled Italian shipwrights to build the necessary galleons.[49]

The Ottomans were more fortunate than their rivals in the Mediterranean in terms of necessary supplies such as timber, flax and hemp as well as tar and iron that was necessary for ship construction. Nevertheless, the quality of Ottoman arms and ships has always remained doubtful. It was often observed that the Naval Arsenal used unseasoned wood while the Venetians had to melt the Ottoman guns seized after the Lepanto because of their poor quality. Apparently, what mattered in the navy was the quantity rather than the quality as was the case in the army. In the lack of a battle-winning weapon, the party with more guns (or warships for that matter) had the advantage over its rivals. This, however, inevitably affected the quality of the Ottoman weapons. Double-front engagements and long wars seem to have forced the Ottomans to compromise the quality. According to one estimate 1,200 ships may have been built and repaired throughout the

[48] Necipoğlu, *Age of Sinan*, p. 167; Ágoston, *Guns for the Sultan*, pp. 53-4; Niccolo Capponi, *Victory of the West: the Great Christian-Muslim Clash at the Battle of Lepanto* (Da Capo Press, 2007).
[49] Ágoston, *Guns for the Sultan*, pp. 55-6; R. Murphey, "The Ottoman Resurgence in the Seventeenth-Century Mediterranean: The Gamble and its Results", *Mediterranean Historical Review* 8/2 (1993): 186-200; Murat Çizakça, "Ottomans and the Mediterranean: An Analysis of the Ottoman Shipbuilding Industry as Reflected by the Arsenal Registers of Istanbul 1529-1650", in Rosalba Ragosta (ed.) *La Genti del mare Mediterraneo* II (1981): 773-88; Onur Yıldırım, "The Battle of Lepanto and Its Impact On Ottoman History and Historiography", in Rossella Cancila (ed.), *Mediterraneo in armi* (secc. XV-XVIII) –tomo II (Palermo: Associazione no profit Mediterranea, 2007), pp. 533-56; Orhan Koloğlu, "Renegades and the case of Uluç/kiliç Ali" (pp. 513-31); Philip Williams, "The Sound and the Furry" Christian perspectives on Ottoman naval organization, 1590-1620" (pp. 557-92) both in the same collection http://www.storiamediterranea.it.

17th century at the Naval Arsenal only –there were more than 70 dockyards in the Empire. In addition, regular and steady supply of fortresses with stockpiles of weapons and ammunition (often outnumbering those of the adversaries) made it difficult to keep to the established standards in arms production.[50]

Eighteenth century Ottoman reforms

Vast territorial losses after the Treaty of Karlowitz (1699, concluded the war with the Holy League, 1683-1699) were compensated to some extent in the first quarter of the eighteenth century. In 1711, the Russian army literally surrendered at the Pruth River and the fortress of Azov on the Black Sea was returned to the Ottoman Empire. While the brilliant amphibious operation that brought the success in the re-occupation in the Morea once more attested to the Ottoman competence in advanced planning and siege warfare, the destruction of the Ottoman army at Peterwardein (1716) at the hands of the Habsburg Prince Eugene was just another demonstration of Ottoman incompatibility in battle tactics based on complex manoeuvres and the bayonet.

The year of 1718 is traditionally accepted as the beginning of the "Tulip Era" which was characterised by an attempt to redefine the imperial identity. Court life particularly was transformed through French-style garden arrangements and baroque architecture based on the plans brought by the Ottoman envoy Yirmisekiz Mehmed Çelebi from France. This era, however, also saw the foundation of the first Muslim press by the Hungarian-unitarian convert Müteferrika, setting up of a fire department in İstanbul, and launching of state-sponsored book translation projects in technical fields from Western languages. The year 1718 also witnessed the arrival of a group of

[50] İdris Bostan, "Ottoman Maritime Arsenals and Shipbuilding Technology in the 16th and 17th Centuries",publication ID: 658, January 2007, FSCT Limited, p. 6. www.muslimheritage.com; Murphey, *Ottoman Warfare*, pp. 14-16 and Ágoston, *Guns for the Sultan*, pp. 190-205.

representatives of Huguenots in İstanbul under the leadership of De Rochefort who, in view of recent French religious intolerance, petitioned the Ottoman court for establishing a Huguenot colony preferably in the Principalities. In return, Rochefort proposed to establish a corps of military technicians in the Ottoman army along the European fashion and undertake the instruction of the army officers in modern military methods. By the time, Huguenots had one of the most developed recruitment system in Europe as well as the ablest military officers. The Sublime Porte rejected the proposal presumably to avoid friction with the traditional ally in the face of the recent humiliation at Patarwardein that caused the loss of Belgrade.[51]

Comte de Bonneval, or *Humbaracı* (bombardier) Ahmed Paşa (1675-1747) no doubt was the most renowned renegade in the service of the Ottomans even in his lifetime. With a group of converts (L'abbe Macarthy [Irish], Marquis de Mornai [French], and Comte Ramsay [Scottish]), he undertook to reorganise the Corps of Bombardiers on the Europen model in 1734. Though it is not clear whether an engineering school (*hendesehane*) was also established within the barracks, it is certain that lectures on geometry, mathematics and practical engineering were held within the corps. Most of the instructors were from among the rank of the *ulama* (men of learning in science and religion) and the education was arranged according to the established rules of a *medrese*. This signified a new departure in Ottoman military traditions since it combined theoretical and practical training in a hybrid institution whose shape was traditional but content was not. After the fall of the palace faction that also favored

[51] Niyazi Berkes, *The Development of Secularism in Turkey* (Montreal: McGill University Press, 1964), pp. 31-2; Aksan, "Ottoman Military Recruitment Strategies in the Late Eighteenth Century", in Erik J. Zürcher (ed.), *Arming the State Military Conscription in the Middle East and Central Asia 1775-1925* (London: I. B. Tauris, 1999), pp. 44-6.

Bonneval, the corps was neglected in the 1740s. Nevertheless, it set the pattern for the technical schools of the next generation with its hybrid character.[52]

The Sublime Porte fought the Habsburgs and the Russians at the same time reasonably well and succeeded to recapture Belgrade in 1739. There was, however, a growing sense of backwardness in technical fields such as mapping and engineering. Thus, the Sublime Porte encouraged innovation through patronage; translations from Western languages focused on the fields of astronomy, geography, medical science, and cannon-casting whereas works of literature and history were translated from Arabic and Persian.[53] Engineering instructor Said Efendi, for instance, wrote books on astronomy, mathematics and land surveying and designed technical instruments for the measurement of the range of a mortar under the patronage of the Court. However, the account of Numan Efendi, who was attached as *imam* (preacher) to the *ad hoc* committee for the delimitation of the Ottoman-Habsburg border (February 1740-May 1741), suggests that technical expertise was underrated among the ruling elite in his time. No translator and engineer were included in the committee so as to reduce expenses.[54] A curious case of technological theft occurred when Numan suspected that the Ottomans were deceived by Habsburg engineers in the survey of a contested island on the Danube. Despite strict measures against technological theft, he scrutinized the Habsburg measurement

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[52] Bonneval served in the Habsburg army for 22 years after his expulsion from France. He quarreled with Prince Eugene and fled to Ottoman realms in 1729. He also attempted to revitalize the Suez and Marmara-Black Sea canal projects since he, as Rochefort, saw economic measures to counter European mercantilist policies indispensable to military reforms see, Mustafa Kaçar, "Osmanlı İmparatorluğu'nda Askeri Teknik Eğitimde Modernleşme Çalışmaları ve Mühendishanelerin Kuruluşu (1808'e kadar)", *Osmanlı Bilimi Araştırmaları* II (1998), pp. 213-21; Berkes, *The Development of Secularism*, pp. 31 ff.

[53] Aydüz, "The Role of Translations in the Eighteenth Century: Transfer of Modern Science and Technology to the Ottoman State", publication id: 626, December 2006, FSTC Limited, accessible at www.muslimheritage.com.

[54] Kaçar, "Osmanlı İmparatorluğu'nda Askeri Teknik", p. 222; Ali İ. Savaş (ed.), *Ebu Sehl Nu'man Efendi. Tedbirat-ı Pesendide (Beğenilmiş Tedbirler)* (Ankara: TTK, 1999), pp. 60-64, 69.

instruments through his English-made binoculars and reproduced their wooden replicas. The Ottoman guards attending on the Habsburg engineers leaked the necessary information on the operating principles of the tools from the handbook in the possession of the engineers, while Nu'man the *imam* took advantage of the drunkenness of General Engelshofen –the chief of the Habsburg committee- to learn how the results yielded by measurement were translated into figures and put on the map. Finally, he set out to survey the island with the help of two Ottoman gentlemen with technical knowledge who joined the camp on his last-minute invitation. The Habsburgs were amused by Numan's wooden instruments at first, but they were insulted when he proved their fraudulent conduct. A just Numan saved the Habsburg engineers from court martial by assuring Engelshofen that they did not sell information to the Ottomans, boasting that Muslims had inherited technical skills from the Andalusians.[55]

In the next three decades after the Treaty of Belgrade (1739) the army and the navy were allowed to fall into decay with a false sense of security based on the victories of the 1730s. Nevertheless, disastrous war with Russia (1768-1774) witnessed the routing of the Ottoman army in the pitched-battle of Kartal (Kagul, 1770) and the sacking of the navy at Çeşme (1770). This war caused the loss of a province with a dominantly Muslim population, namely, the Crimea. Historians have agreed that such humiliations served as a catalyst for military reforms. The Ottomans proved no exception. Baron Francois de Tott and Saint-Remy undertook the reorganisation of the foundry and the construction of a new one as required by the Gribeauval system of boring out the gun barrel from the solid. He founded the short-lived School of Artillery which was to evolve into the Naval

[55] Numan had some knowledge of geometry and mathematics from the *medrese* years. Savaş (ed.), *Ebu Tedbirat-ı Pesendide*, pp. 60-69, 82-92.

Engineering Academy with a curriculum inspired by the 1765 French regulation and the *medrese* system. In addition, he established a new field artillery corps with Lieutenant Aubert in 1770-74. By the commissioning of Tott, the Ottomans rescinded the principle of conversion for foreign officers serving in the military.[56]

The 1780s witnessed the Ottoman acceptance of a French military mission which was unprecedented in Ottoman history. After the Russian annexation of the Crimea in 1783, the French government revised its Eastern policy according to which the Ottoman Empire was to be strengthened militarily against Russia through technical assistance. A group of French officers in the Antoin Chaboit mission undertook to reinforce many major fortresses including Hotin (Khotin), Özi (Ochakov) and those along the Straits and renovate the gun foundry and the naval arsenal.[57] Acceptance of the French mission encouraged Duke de Luxembourg, a relative of Louis XVI, to visit Istanbul with an interesting military project in 1784. He related the Ottoman defeats with the incompatibility of the Ottoman troops in the contemporary European warfare. Accordingly, he was to raise an Ottoman force of 1,200 men in Rhodes or Crete. Troops were to be disciplined and drilled by French officers. However, the reforming Grand-vizier Halil Hamid Paşa turned down the proposal, for he was aware of the French ambitions in the Levant.[58]

Another group of French officers arrived in İstanbul the same year under the leadership of De Lafitte Clavé with a French geographer. These officers were specialists

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[56] Aksan, "Breaking the Spell of the Baron de Tott: Reframing the Question of Military Reform in the Ottoman Empire, 1760-1830", *International History Review* 24 (2002): 253-77.
[57] Aksan, *Ottoman Wars, 1700-1870: An Empire Besieged* (London: Pearson Longman, 2007), pp. 186-206; Finkel, *Osman's Dream: The Story of the Ottoman Empire, 1300-1923* (London: John Murray, 2006), pp. 372-413.
[58] Aksan, "Choiseul-Gouffier at the Sublime Porte 1784-1792", in Sinan Kuneralp (ed.), *Studies On Ottoman Diplomatic History* (İstanbul: The Isis Press, 1992), p. 31.

in siege techniques and fortification. They supervised a number of fortresses in the Black Sea region. Meanwhile, Monnier, Aubert and Granper were commissioned for re-vitalising the neglected field artillery corps together with some other experts in ship construction and gun-casting. De Lafitte, Monnier, and Mehmed –a Prussian convert- established the School of Fortification with the intention of training engineer officers expert in siege techniques and fortification. The total number of students was not beyond fifteen but courses were held open to whomever desiring to attend. An Arabic-script press was set up in the French Embassy and two major textbooks were printed. As was the case in the Naval Engineering, the staff was predominated by the *ulema* members. Another unrealized project was the sending of thirty Ottoman officers to France for training. The French military missions included construction and foundry workers, carpenters and shipwrights as well as officers. France withdrew its technical mission when the Ottomans entered war with Russia and the Habsburgs in 1787 since Maria Antoinette was the sister of the Habsburg Emperor Joseph II.[59]

All these technical reforms culminated into a full-fledged reform programme –the New Order (*nizam-ı cedid*) encompassing all military institutions in breadth and scope during the reign of Selim III (1789-1807). The foundation of a new engineering school for the army (1793) was followed by the establishment of the New Order army with Western-style uniforms, equipment, and training. While the first recruits included Russian and Habsburg prisoners of war, the army later relied on the Turkish peasants and tribesmen of Anatolia. Thus, reforms were extended to core services of the army from the technical corps. The reorganisation of the naval arsenal and the gunpowder works were

[59] Consult Frédéric Hitzel, *Le Role Des Militaires Francais A Constantinople (1784-1798)* (Université de Paris-Sorbonne, Moemoire de Matrise D'Histoire, 1987); Aksan, *Ottoman Wars*, pp. 198-206.

among the successes of the reform programme. The Swedish engineers constructed a dry dock in the naval arsenal. The French naval engineers served with Ottoman masters under Le Brun and built roughly 50 warships on the latest French design which made the Ottoman navy second to the British navy in the Mediterranean particularly after the Battle of the Nile.

Ottoman arms and ammunition imports had reached at considerable levels in the second half of the 18th century especially due to the wars with Russia and war with France (1798-1802). The hydraulic Azadlu gunpowder plant founded in the 1790s increased the annual production to 564 metric tons by 1800 –still less than one-third of France's annual production but certainly higher than the former figure of 169 metric tons.[60]

As for the artillery, Ottoman guns displayed considerable diversity in calibre although there was a clear tendency towards standardisation throughout the 18th century. Implementation of the Gribeauval system fell short of increase the mobility of the Ottoman field artillery drastically since Ottoman field guns and carriages were still too heavy, almost twice as much as its European field artillery pieces. This was due to the hybridisation of European and Ottoman casting techniques in the foundry; Ottoman casters were biased in favor of thicker priming pans and longer barrels. By early 18th century, the degree of hybridisation was such that "the Ottoman pattern" in artillery was likely to be a combination of a French style gun featuring the Turco-Islamic crescent and

[60] Ágoston, *Guns for the Sultan*, pp. 158-63; annual powder production of France rose from 1.7 million pounds in 1775 to roughly 4 million pounds (1,816 metric tons) in 1788 owing to the reforms of Lavoisier. In contrast, the annual Ottoman production decreased from 761-1,037 metric tons (17th century); Jack Kelly, *Gunpowder: A History of the Explosive that Changed the World* (London: Atlantic Books, 2004), p. 165.

star; a ramrod in Habsburg style; a carriage based on the Habsburg and/or French model and painted in yellow following the Habsburg national pattern.[61]

Various works on military arts and sciences including those of Vauban were translated from Western languages in a more systematic manner in the press founded in the modern barracks, laying the necessary infrastructure for modern sciences. Although Selim was toppled by a popular revolt in 1807, the press and the engineering schools were left unharmed as was the case in the 1730 Rebellion that had brought the end of the Tulip Period. Ottoman reforms of this century rather had an evolutionary character; while they did not radically alter the configuration of the Ottoman social, economic and political system in the short run, they certainly resulted in the transformation of the whole system in decades. These schools and the permanent embassies established in Paris, London, Berlin, and Vienna raised a new generation of Ottoman engineers and diplomats with Western-style thinking who would shape and carry out the decisive reforms of Mahmud II after the abolition of the Janissary corps in 1826.[62] The shift from voluntary recruitment to obligatory conscription in the New Order army eventually resulted in the emergence of a national Muslim army in the reign of Mahmud II.[63]

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[61] The pieces Tott and St-Remy cast in 1772/3 were lighter than those cast in 1793/4, see Turgut Işıksal, "III. Selim'in Türk Topçuluğuna dair bir Hatt-ı Hümayunu," *İÜEF Tarih Dergisi,* 8 (11-12), 1955, pp. 179-184; in the 1800s, an Ottoman field gun weighed 486 kg and 808.6 kg with its carriage, see Şakul, "General observations on the Ottoman military industry, 1774-1839"; M. Kaçar, "Osmanlı Ordusunda Görevli Fransız Subayı Saint-Remy'nin İstanbul'daki Top Döküm Çalışmaları (1785-87)", *Osmanlı Bilimi Araştırmaları* V /1 (2003): 33-50.

[62] Levy, p. 239.

[63] Aksan, *Ottoman Wars*, pp. 306-43.