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Conference Report

Fortification in Focus - Mathematical Methods in Military Architecture of the 16th and 17th Centuries and their Sublimation in Civil Architecture

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In recent years the importance of mathematics as a basic discipline not only for the sciences but also for the humanities has been rediscovered and become the subject of interdisciplinary investigations. Two examples among many are the publication *Die mathematischen Wurzeln der Kultur. Mathematische Innovationen und ihre kulturellen Folgen* (The mathematical roots of culture – mathematical innovations and their cultural consequences) edited by Jochen Brüning and Eberhard Knobloch, Munich 2005, and the conference “Was zählt. Präsenz und Ordnungsangebote von Zahlen im Mittelalter“ (What counts. The presence and medial function of number in the Middle Ages) held 2006 in Berlin. The specific role of geometry in the field of landscape architecture has been pointed out lately and rather pertinently by Volker Remmert in his article “Il faut être un peu géomètre” - Die mathematischen Wissenschaften in der Gartenkunst der Frühen Neuzeit” (One has to be a bit of a geometer – the mathematical sciences in the art of the garden in early modern age), published in the catalogue of the exhibition “Wunder und Wissenschaft – Salomon de Caus und die Automatenkunst in Gärten um 1600”, Düsseldorf 2008, (Miracle and science – Salomon de Caus and the art of automatons in gardens of the 1600s).

“The principal aim of mathematics is not application, but the creation of culture” – the idea embodied in this statement by mathematician Gerhard Frey can be traced back to the beginnings of human history. From the times of the Babylonians and Egyptians, the discovery, the knowledge and the application of mathematics to daily life was the driving force behind all technical innovations of all cultures. One significant example of this development was the changes of fortification systems around 1500, brought about the fall of Constantinople as a result of the hail of bullets fired by the Ottomans in 1453, which made it obvious that city walls built in the Middle Ages were no longer strong enough to

provide protection from artillery fire. Three cultural factors strongly influenced the new developments. First, the Gutenberg press was invented, and the printing of books on paper facilitated the circulation of knowledge. Euclid's *Elements* was the first book to be published and widely available beyond the confines of monastery libraries and the few private libraries of privileged scholars. The knowledge of geometry, up to then taught as part of the *artes liberales* at the universities, became widespread, with far-reaching consequences for cultural developments. Second, the invention and development of perspective drawings during the fifteenth century created a new visual awareness of space and its representation. Finally, the rediscovery of Platonic philosophy appears to have compelled the introduction and transmission of geometrical forms into applied arts and architecture.

The idea for the "Fortifications in Focus" conference came from the meeting of Bettina Marten, Michael Korey and Ulrich Reinisch, who were all working on fortifications but from different points of view: Bettina Marten, an art historian, focuses her investigations on the relationship between mathematical knowledge and its influence on military architecture; Michael Korey, a mathematician, is interested in the instruments of measurement and their meaning within the courtly circles; Ulrich Reinisch, also an art historian, is investigating the transmission of elements and methods appertaining to military architecture into civil architecture and landscape architecture. The goal of the conference, to which were invited historians of science, art, and architecture, as well as experts in fortification, was to illuminate aspects of mathematics during the period in question and the use of mathematical instruments, as well as the concomitant military, visual, and rhetorical claims in fortification and related architectural fields.

In their introductions, the organizers explained the fundamental ideas underlying their interdisciplinary approaches. These were then expanded by the speakers who followed. Bruno Klein (TU Dresden) addressed the problems of the history of the visibility and non-visibility of military architecture and formulated on this basis a program to investigate the subject of the meeting within the history of culture and science. Bettina Marten (TU Dresden) outlined the many and diverse interdisciplinary starting points connected with the topic of military architecture, including the history of mathematics, of architecture and of the theory of architecture, of military history, of science and of social science; all of these make evident the far-reaching relevance of fortification. Stefan Bürger (TU Dresden) concentrated his observations on the heterogeneous understanding of theory and practice and the divergent positions of the engineers and theorists caused by diverse methods in the field of fortification building; these differences already existed in the sixteenth century, and formed the basis for the divergences today. On the basis of the psychoanalysis of Sigmund Freud, Ulrich Reinisch (Humboldt-University Berlin) reflected on the terms "anxiety" and "sublimation" which dominated the conditions (of anxiety) in the Middle Ages and how these were overcome by intellectualizing them as methods of defensive action, which launched the changes of the defensive systems in the 1500s. Michael Korey (Mathematic-Physical Salon of the State Collections of Art Dresden) referred to the role of the courtly collections of scientific instruments and libraries. The collections of contemporary treatises on measurement and fortification architecture constituted centres of innovative intellectual activity within the European aristocracy; shared knowledge was supported by the exchange of precisely-worked and lavishly decorated instruments as gifts.

The precise categorizations and descriptions of the complicated and widely branching system of Early Renaissance knowledge led to military architecture being classified as an operative art between mathematics as *scientia contemplativa* and crafts as *ars mechanica*. Geometry functioned as a connecting link because of its practical application in the field of measurement on the one hand and through literary tradition on the other hand, both as a method of cognition of nature and as a foundation for human activity (Orietta Pedemonte, Genova). This is the explanation of the analogies established during the sixteenth century between military architecture and machine construction, between military architecture and civil architecture. The basis of all these areas is operative or practical geometry, which had been mastered by both military engineers and architects (Tobias Büchi, Zürich). Because of this, the transmission into civil and landscape architecture seems to be a natural consequence, because these used the methods and artistic elements developed in military architecture, transferring the specific symbolic elements of strength and power to civil architecture (Christof Baier, Marion Hilliges, Judith Schlereth, all Berlin). The mastery of geometry as part of speculative science as well as part of the *artes mechanicae* made it possible for artists like Leonardo da Vinci, Albrecht Dürer and Michelangelo Buonarroti to deal with apparently incompatible disciplines such as the arts, military architecture and machine-building. Similar to Albrecht Dürer, Leonardo da Vinci was convinced that the perfect design for a fortress respected the ideal form of the circle, a form he also used for mobile artillery weapons, a prototype of modern tanks (Kim Williams, Torino).

Of fundamental importance in the process of designing are the visual representations, first in perspective drawings and second in three-dimensional models. Whereas the models were built to show volumes, the function of the different parts of the fortifications, and their integration into the surrounding topography, the drawings developed more and more into the preferred medium for representation, because, taking advantage of a bird's eye view, they provided the best picture of the complexity of the fortresses and their extension into the surroundings. A new awareness of space and territory was thus created. Perspective drawing as a medium was used as an instrument for presenting the functional aspects of the bastioned fortification system in a more credible way, because the applied "objective" mathematical methods were more suitable than free-hand visualizations of earthworks, which were practice orientated and of rounder shapes (Stefan Hoppe, Köln; Ralf Gebuhr, Cottbus). The radical change in military architecture has also been connected with the changes in the process of designing, which came to include the moment of movement as well: the design lines were contemporaneously lines of movement because they were identified as lines of fire, as the analyses of Galileo Galilei's treatise of fortification (1592/93) have shown (Horst Bredekamp, Berlin). The search for security within the idea of order in geometrical form was influenced, on one hand, by the rediscovery of the sixth book of the *Historíai* written by Greek historian Polybius and, on the other hand, by the acceptance of geometry as the tool for objective scientific discoveries of natural laws, which was understood to be and taught as a secure foundation (Nicola Aricò, Messina; Bernd Roeck, Zürich; Jeroen Goudeau, Deventer). The range of the intellectual performance and the authority of mathematical methods related to fortifications in regard to social relevance and importance can be demonstrated by comparison with other arts deemed mathematical, such as music or sundialing, in view of the relationships between mathematicians, practitioners, artisans and the public (Stephen Johnston, Oxford).

Aristocratic education was founded on the supposedly unalterable knowledge of mathematics and fortifications. The sons of European courts acquired their knowledge at

the hands of tutors who were experts of mathematics and fortification, such as Galileo Galilei for the Medici family or Carlo Thetis for the Dukes of Saxony. Among the materials used for teaching were treatises containing theoretical and practical instructions, such as, for example, Girolamo Cataneo's *Arte de militare* or *Arte de misurare* (Pascal Briost, Tours). The members of the aristocracy were also military commanders, who were personally involved in battles. One of their most important weapons was the dagger, which could be transformed into a compass, the traditional allegorical symbol of geometry in the sixteenth century. The technological and cultural changes, in which the keys to political and military power were entrusted to geometry, implied an extraordinary convergence of technical and scientific capabilities ranging from perspective drawing to topographic surveying, from calculation to measurement (Filippo Camerota, Florence). The far-reaching consequences of these changes on the political reality were shown by the analyses of the system of fortifications built by Emperor Charles V in the southern parts of the old Netherlands. The fortified cities of Mariembourg, Hesdinfort, Charlesmont and Philippeville, founded between 1546-1560 on strategically important sites, all had polygonal layouts with radial or orthogonal street systems. The construction of these cities, under the direction of Italian or Dutch engineers, took many years and consumed significant sums of money (Bernhard Roosens, Gent/Berlin).

The meeting began and ended with excursions: The first was a guided tour to the remaining parts of the fortifications of Dresden at the Brühlsche Terrasse near the river Elbe, where Dr. Heiko Berger (Militärhistorisches Museum, Dresden) gave an introduction to the system of artillery weapons as well. The other excursion went to Theresienstadt in the Czech Republic. This fortified city, built 1780-1790 by Emperor Josef I, has survived almost intact, but has been stigmatized because it was used as a Jewish ghetto by the German Nazis from 1941 to 1945. Astrid Debold-Kritter, who has been investigating the original eighteenth-century plans for many years, explained the concept of the urban structure.

The "Fortifications in Focus" conference was organized by Dr. Bettina Marten (Institut für Kunst- und Musikwissenschaft der Technischen Universität Dresden), Dr. Michael Korey (Mathematisch-Physikalischer Salon der Staatlichen Kunstsammlungen Dresden) and Prof. Dr. Ulrich Reinisch (Kunstgeschichtliches Seminar der Humboldt Universität Berlin). Financial support was provided by the Gerda Henkel Stiftung, Düsseldorf, and the Gesellschaft der Freunde und Förderer der TU Dresden. The conference project was given an award in the competition "Kopf und Zahl" by the German Ministry of Education and Investigation, announced on occasion of the scientific year of mathematics. The papers that resulted from the presentations at the conference are now in preparation for publication, scheduled for the 2009.

About the author

Bettina Marten studied art history, archaeology, philosophy and social sciences at the University of Hamburg with professors Horst Bredenkamp and Martin Warnke. She wrote her doctoral thesis on the fortifications built by Vespasiano Gonzaga for Philippe II in Spain and Italy. Her principal interests are urban development from the Middle Ages onwards, including contemporary movements; Spanish art history; processes of transculturation. She teaches at the Universities of Dresden and Frankfurt/Main.