GASPAR MONGE – THE FOUNDER OF DESCRIPTIVE GEOMETRY

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Abstract*: We live in hectic times, leading our lives day-by-day and hour-by-hour. Thus, we seldom have a cause to look back. It there is one thing that we miss by overlooking the past that is the realizing of just how much we don't know. Compressed in a few pages, I'm bringing to your attention the most critical scenes in the life of a man whose existence was as tumultuous and ever changing as the times he lived in, Gaspar Monge. Historical events and figures enter the stage of our character's life, do a quick jig and then leave. His world of ideas, however, is everlasting. Be it in the field of geometry or physics, chemistry or military engineering, Gaspar Monge's theories strongly echo to these days.*

Key words*: Gaspar Monge, descriptive geometry, military engineering, field fortifications.*

The historians of the French Revolution and the Napoleonic Empire are well acquainted with the figure of Gaspar Monge, whose career spans the aforementioned periods, on account of the tribute paid by his scholars later to become academicians (such as Charles Dupin and Francois Arago), and of the biographical studies by Louis de Launay (1933) or Renee Taton (1951). But rarely has the biography of this great mathematician been made the object of an article in one of our technical publications (the scarcity of the Romanian materials on this subject confirms it). Yet, our only claim is to simply rediscover a long-ignored character, who did not content himself with studying the lines of curvature or partial differential equations, but also consented or decided to work in such capacities as: Minister of the Navy, Director of the newly founded *L'École Polytechnique*, head of *La Commission des Sciences et Arts* in Italy, and President of *L'Institut d'Egypte*, to name but a few.

With the exception of those who share a passion for geometry, few of us know that Gaspar Monge is actually the one who laid the foundations of descriptive geometry, upon which modern mechanical and architectural drawing is based. According to the words of this *grand homme*, quoted here from Louis de Launay's biography *Un grand français: MONGE. Fondateur de L'École polytechnique*, "this art (descriptive geometry) has two main objectives. The first one is to represent, with precision, in drawings with only two dimensions, objects which have three dimensions. The second objective is to deduce from the exact description of the geometrical figures everything that inherently derives from their forms and their respective positions".

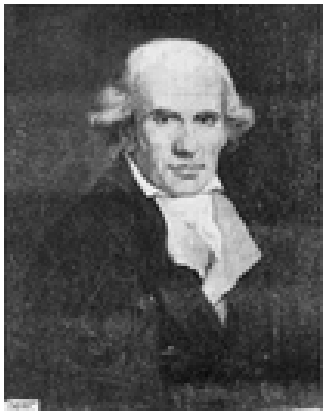


Fig. 1 Gaspar Monge

Simple words, yet underlying a fundamental principle, which Monge first has the chance to carry out in action in 1766. The setting for this „scene" is the *Royal Military Engineering School* in Mézières, where our character, who at the age of 16 was already teaching physics at *Le College Oratorien de*

Lyon, is now not a student officer, but .... "aperson skilled at handling the pencil". Employed as a draftsman at the recommendation of Colonel Du Vignau, the first to notice Monge's graphic talent after seeing his large scale plan of the town of Beaune, Monge is one year later required to draw the plan of a fortress based on data supplied by observations.

In the early 18th century, a time when the ruler and the compasses are the only aids available, several attempts were made at Mézières to represent graphically the relief of the battlefield terrain. The first commandant of the school, De Chatillon, had the idea to represent the terrain under the form of some marked projections. An engineering officer, Milet de Mureau, improved the system by representing the marked points onto a projection plane, as we would call it nowadays. Thus, the defining of a tangent to a curve in a vertical plane, which would indicate the areas protected against the enemy fire, was possible. Yet, in case the plane left a dangerous point above it, the analysis would start all over again with a new, conveniently chosen tangent plan.

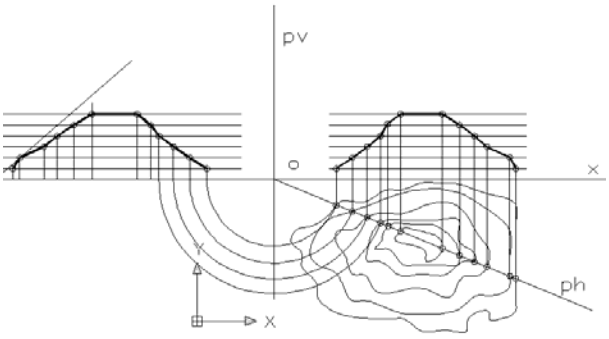


Fig. 2 The Monge Projection

Monge's idea is to represent this entire fascicle of lines in a unitary system, by using two orthogonal planes, whose intersection has since been called "ground line" (Figure 2). It is, thus, possible to graphically solve, by means of a ruler and compasses, any terrain problem that might arise.

Today, we regard these naïve attempts with condescension, but given the importance of Monge's first work on the direction of his future geometrical researches and not only, we believe it is worth emphasizing it. For it is this very approach that led to solving ever growing complex issues related to the intersection of solids and planes, and the deciphering of unsolved algebra problems by using graphical methods, in other words, to the emergence of the descriptive geometry as a fundamental subject very similar in form to what we study nowadays.

Monge's method of graphical representing the geometry of field fortifications, though promptly embraced by the French military because of its simplicity, is not fully disclosed before the 1790's for military reasons. Nevertheless, the teaching career at Mézières finally opens to him, serving as a springboard to his future scientific activity: the young man who was previously denied admission as a student officer on account of his humble origins, being merely tolerated at an annexe of the school where surveying and drawing were taught, becomes a substitute teacher in 1768. Several years later we encounter Monge in a more dignified position, that of Mathematics and Physics professor at the same *Royal Military Engineering School* in Mézières. Elected correspondent of the Académie de Sciences in 1772, and eight years later assistant geometer at the same prestigious institution, Monge embarks on a scientific journey devoted to the study of "pure geometry", physics, as well as other disciplines.

In the 18th century and the beginning of the 19th, *L'Académie de Sciences* in Paris is a genuine office of inventions. All new ideas are here submitted, any unprecedented discovery is first endorsed here. Annually, each academician is expected to submit ten to fifteen reports on the most diverse subjects. Launay's biography cites randomly some of the projects that Monge is charged with at the beginning of his scientific career, with the mere intention of showing us the kind of „intellectual gymnastics" the French academicians were subjected to. These projects are varied in scope, ranging from a machine for draining harbors, grain mills and grinders, to a machine for towing cargo ships. No wonder that these new extra duties, combined with his appointment as an examiner

of the Navy cadets in 1783, take up most of Monge's time, to the dissatisfaction of the management of the military school in Mézières . As shown in a letter dated 26 November 1783, the commandant of the school, M. de Villelongue, chiefly complaints about the scarce time spent by Monge with the military students: *"Ever since Mr. Monge was drawn into the scientific circle attached to the Academy, his talents have remained untapped by our students […] Because the only time he comes here is in summer, when we are on the field providing training in reconnaissance and siege simulation, how can he teach our students on his other specialties?"* After four years, in which Monge leads a sort of a double life - Paris becomes his permanent residence, whereas Mézières turns rather into "a summer holiday resort" - the breakup is inevitable.

In the years preceding the outbreak of the French Revolution, Monge publishes several more reports on integral calculation and analytical geometry. Moreover, his interest in physics and chemistry leads to a series of experiments on the effects of optics and electricity, meteorology, molecular attraction, the inflation of balloons with hydrogen, and the composition of water, to name but a few. In 1785, Monge becomes associate member of the Académie de Sciences, on which occasion, together with other famous scientists (Lavoisier, Fourcroy, Berthollet and Vandermonde), he approaches a new project: the study of founding. In more precise terms, the project aims at inquiring about the production of steel and cast iron, the fusion and combination of metals, and the combustion of various carbons. This is a prolific period not only in terms of scientific researches, but also social connections in the most diverse spheres of influence, which could explain to a certain extent the sudden, and quite surprising evolution of our brilliant geometer.

The capture of the Bastille on July 14th 1789 sends shockwaves throughout the nation and Europe. Like the rest of the French, Monge adheres to the ideals promoted by the grand social movement. To quote his biographer's words, our mathematician "loved democracy and equality just as he loved the results of a geometrical demonstration". Apparently, the first three years of the Revolution bring no major transformation in the life of our character, who is still engrossed in his academic works, this time as a member of the commission assigned to standardize weights and measures. The date of 10 August 1792 however, brings about the abolition of monarchy and, along with it, Monge's appointment as a Minister of the Navy. But this new office does not come as recognition of Monge's political merits, for he had none. It is rather the result of a concourse of events: in those troubled times, elections were precipitated; Monge's experience as an examiner of the Navy cadets, coupled with the proposal made by Condorcet, he himself a secretary of the National Assembly and a colleague at the *Académie des Sciences*, sufficed to instate Monge. In reference to the election procedures of that time, Mme Roland, the wife of the Girondist minister of the interior, takes a harder view: *"somebody has the idea, then the others have a taste of it; no serious candidate is proposed, and so, a person whom nobody dreamt of appointing a quart of an hour before, ends up governing a country."*

Poignant criticism, though capturing the reality of the day. For how else could we explain, for instance, Monge's signature on the decision of execution of Louis XVI, or the lamentable naval expedition to Sardinia? Nonetheless, let us not fall into the trap of judging Monge's actions from our time perspective. Is this not the time when the mob violence is reigning, when despots are struggling for control over the direction of the Revolution, when Terror is raging within the city walls? Louis de Launay is among the few biographers to resort to mitigating circumstances when commenting on this period in Monge's life. He attributes such insuccess to the lack of fierce energy and strong will, prerequisites to being a good politician. Monge, on the contrary, "made the mistake, inconceivable in that era, to show so much kindness that it was taken as a weakness". "Personally, the author continues, I think he [Monge] has done everything in his power … but within the strict limitations

imposed on him, and in accordance with his personal opinion, i.e. the opinion dictated by the ruling majority and tyranny. And isn't this opinion that is always most deplorable in times of war?"

Only eight months after his designation as a ministry of the Navy, Monge decides to leave the high office for a position more adapted to his talents, this time in the field of iron metallurgy. It is a well known fact that war has always generated a need for technical applications. A war cannot be fought with soldiers only; explosives and cannons are of utmost importance. It is in this context that Monge takes up work on various military projects related to arms and explosives, introducing methods of scientific precision in the process of making artillery equipment. From 1793 to 1794, as a member of the Committee on Arms, Monge coordinates work in the armaments workshops in Paris and helps to develop military balloons.

In these times of social unrest, when all education is suppressed, with schools and convents used as prisons, the aspiration to an intellectual career seems almost utopian. Paradoxical as it may sound, out of this war drama, two peaceable creations emerge: *L'École Polytechnique* (1794) and *L'École Normale* (1795). And these creations are inextricably linked to Monge's name.

L'École Polytechnique is based upon the concept of reuniting both civilian and military engineers under the name of national engineers: since the various works of military, civilian and hydraulic architecture share the same principles and theories, it is only natural for the introductory studies to be common as well. Not only does Monge have a major influence in setting up this new institution by using his experience at Mézières to good effect, but he is also appointed as an instructor of descriptive geometry to train future teachers of the school. Monge's lectures on infinitesimal geometry were to form the basis of his book *Application de l'analyse à la géométrie.* The other educational establishment, *L'École Normale*, is set up to train secondary school teachers. Prestigious researchers such as Berthollet, Daubenton, Laplace, and Lagrange are appointed as members of the teaching staff. Among them, our Monge - needless to say that he is tasked with giving lectures on descriptive geometry.

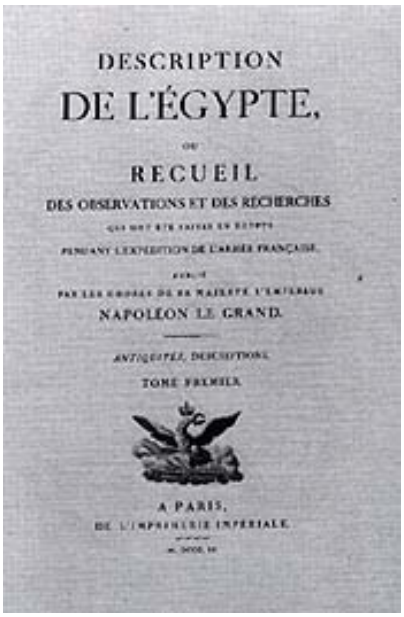
The end of the year 1795 marks a revival in interest in Sciences, Letters and Arts. The old régime's *Académie des Sciences* resumes its activities under a new name, *L'Institut*, after a three-year break. The old academic committees are reorganized, with Monge and Berthollet as main coordinators. But our character is not going to enjoy for long this tranquil and scientific existence. Towards the end of May 1796, he leaves France without knowing that his long absence would give his life a novel orientation, as illustrated in the last two stops of our biographical journey.

The first one is in the newly conquered Italy, where Monge, together with other French scientists and artists, is commissioned to compel the various Italian towns to offer pictures, sculptures, or other works of art that they might possess, as a present or in lieu of contributions to the French Republic. Biographers such as J. O'Connor and E. F. Robertson condemn Monge for having presided over the "cultural pillage of Italy". In contrast, Louis de Launay refers to this "artistic mission" as a common practice, whose origins can be traced back to the invasion of Belgium (1794), when a commission comprising amongst others Charles Delacroix (the father of the painter) was officially sent to collect work of arts in the Netherlands. According to the same biographer, the campaign to Italy simply brings this method into widespread use, making it official (the confiscation of the artistic works became one of the provisions of the treaties imposed on the conquered).

But let us turn our attention to another facet of Monge's presence in Italy. It is here that our mathematician becomes the confidant of the ideas and projects of none other than the general of the French army in Italy, Napoleon Bonaparte. Monge's letters to his wife, as well as Napoleon's correspondence with Paris pinpoint an audacious plan shared by the two, that of defeating England in Egypt and building a modern European-style state, controlled by France, at the axis of all trade between Europe, India and the East. So it

should not come as a surprise the fact that Monge decides to accept, two years later, Napoleon's request to accompany him on the Egyptian expedition, as well as to assist him in the preparations.

It is not military significance that the campaign of Egypt (1798 - 1799) is mostly associated with, but rather with its indelible marks left on the scientific and historical fields. As part of the expeditionary force, *La Commission des Sciences et Arts*, comprising 150 men drawn from *L' Institut de France*, and known popularly as *les savants*, makes a thorough survey of every aspect of the country, including its antiquities. The work is coordinated by the *L'Institut de l'Egypte*, established by Napoleon in Cairo, with Monge as president. The official outcome is the masterful publication of *Description de l'Égypte, ou Recueil des observations et des recherches, qui ont été faites en Égypte pendant l'expédition de l'Armée Française*, the first comprehensive description of ancient and modern Egypt.


DESCRIPTION

DE L'ÉGYPTE,

RECUEIL

DES OBSERVATIONS ET DES RECHERCHES

NAPOLEON LE GRAND

A PARIS,

Fig. 3 "Description of Egypt" – original book cover

Of the outstanding achievements of the savants, unmatched by any other nation during the same period, the most memorable remains the Rosetta Stone. Though ceded to the English as part of the terms of the French capitulation, it is a French scholar, Jean François Champollion, who later deciphers the hieroglyphs on the stone by using copies of its bilingual text. Needless to point out that this discovery, directly linked to the Napoleonic expedition, brought about the emergence of Egyptology as a scientific discipline.

Once the military operation in Egypt fallen short of its objectives, Monge returns to more familiar surroundings. In the years to come, our character enjoys the privileges of his friendship with the now emperor Napoleon, who appoints him as a senator in the newly formed government. In 1808, he even receives the title of *Comte de Péluse*.

But all these privileges will cease to exist the moment the monarchy is restored to France, in 1814. The turbulent years surrounding the French Restoration are also the years of Monge's fall. Expelled from *L'Institut de France*, and deprived of the honors bestowed upon him by his influent protector, our character's life becomes desperately difficult.

Moreover, his health collapses. When all the clocks finally stop for our character on 28th of July 1818, his only mourners are his beloved students. For it is not a defrocked man that they grieve, but a brilliant geometer whose world of ideas influenced the world we live in nowadays.

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