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► **To cite this version:**

Laurent Polidori. ON LAUSSEDAT'S CONTRIBUTION TO THE EMERGENCE OF PHOTOGRAMMETRY. ISPRS International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 2020, XLIII-B2-2020 (1), pp.893-899. 10.5194/isprs-archives-XLIII-B2-2020-893-2020 . hal-02994811

HAL Id: hal-02994811

<https://hal.science/hal-02994811>

Submitted on 24 May 2024

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ON LAUSSEDAT'S CONTRIBUTION TO THE EMERGENCE OF PHOTOGRAMMETRY

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Commission II, WG II/8

KEY WORDS: Laussedat, metrophotography, photogrammetry

ABSTRACT:

The French officer Aimé Laussedat (1819-1907) is often considered as the “father of photogrammetry”. Indeed, he was the first to use photographic images for topographic surveys as early as 1861, based on a technique he called metrophotography, which he had already implemented with hand-drawn perspective views of edifications and mountainous landscapes. However, the development of analog photogrammetry at the beginning of the 20th century is not a direct evolution of Laussedat’s method and we can wonder what is his actual contribution to the emergence of photogrammetry when the first stereocomparators were created. Based on the influence of precursors like Beautemps-Beaupré and Arago, he developed a very innovative method but his main contribution remained mainly instrumental and he ignored some concepts or technologies which were available, like error computation, stereoscopy and aerial photography. These observations allow a more nuanced appreciation of his contribution.

1. INTRODUCTION

Who is the father of photogrammetry? The name of the French officer Aimé Laussedat (1819-1907) is often cited. Much has been said and written about Laussedat at the occasion of his bicentenary (Granshaw 2019, Polidori 2019), and although his prominent role in the first attempts to make measurements in perspective views was clearly recalled, it was also an opportunity to discuss in more critical terms about his actual contribution to the emergence of photogrammetry and the nature of his legacy. The international literature of photogrammetry often cites Laussedat as “the first to utilize photographic images to derive topographic information” (Koneckny 1985). However, the link between the experimental technique he called metrophotography in the 1860s and the emergence of photogrammetry in the 1900s is not straightforward. After recalling the main steps of Laussedat’s scientific and military career, his role in the primitive history of photogrammetry is analysed with an attempt to identify prior influences and the impact of the technological and political context of his time. Finally, Laussedat’ actual contribution is discussed.

2. SCIENTIFIC AND MILITARY CAREER

In 1842, after two years of study at the École Polytechnique in Paris, lieutenant Laussedat was assigned to the corps of engineers where he spent his entire military career. He was first assigned to the fortifications of Paris where he participated in the construction of the fort of Romainville, then in Bayonne (French Pyrenees) for the recognition of the Franco-Spanish border and the study of the establishment of a stronghold in Cambo. He was then responsible for making topographic surveys, and since then, he began to think about the alternative approaches that he was to develop during several decades in order to make topographic surveys more accurate and efficient, particularly in mountainous areas.

Having become a captain, his research program was then drawn up: his aim was to replace direct, tedious and imprecise topographic measurements, by measurements made in

perspective views, initially hand-made drawings done with a camera lucida and later, photographic images as soon as photography would have become technically more operational.

Based on the experience gained in the first years of his career, he began to dedicate himself to his research as soon as he returned to the fortifications of Paris in October 1848 - a period of great exaltation for this young republican with the advent of the Second Republic.



Figure 1. Captain Laussedat in 1852

Since he had deplored the slowness of traditional topographic methods, he probably thought very early of using photography, in which he should be able to locate terrain points by geometric intersection. The idea had already been suggested by the great scientist Arago to promote the daguerreotype as early as 1839. But the optical lenses were primitive, their angular field was too narrow and the equipment for acquiring photographs in the field was too bulky. Pending the improvement of the photographic equipment, Laussedat therefore began his research with perspective views drawn by hand. He was reusing an idea of the hydrographic engineer Beautemps-Beaupré, but he improved it by using the camera lucida of Wollaston, which allows a rigorous perspective so that surveys could be carried out by soldiers without any help from artists. By publishing surveys made on military fortifications (Mont Valérien, Fort de Vincennes), he demonstrated the potential of his method, which he called iconometry.

After the coup d'état and during the Second Empire (1851-1870), his republican convictions were not compatible with a position of military officer, so that he became an assistant professor (under the astronomer Hervé Faye), then a full professor, at the École Polytechnique where he had previously been a student. He had two main activities. On the one hand, he became a renowned scientist in the field of geodesy and astronomy, with multiple international partnership. He took part in the new triangulation of the kingdom of Spain and conducted an expedition to Algeria where he observed a total solar eclipse using a photographic method. His name is even cited in Jules Verne's famous novel, *From the Earth to the Moon*, published in 1865 i.e. when he was only 46. On the other hand, he carried out a continuous and important research on the topographic applications of photography. He tested a method he would call metrophotography: the intersection calculation which he had already applied to the perspective views drawn with the camera lucida, were now applied to photographs of urban or mountainous landscapes. The demonstrations of feasibility which he made in Paris and Buc (near Versailles) in 1861 allowed him to convince the French army to set up a specialized brigade, which was to be led by Captain Javary. Promoted to battalion commander in 1863, Laussedat continued his scientific activities until the end of the imperial period.

Laussedat's research was interrupted by the Franco-Prussian war in 1870. He resumed military functions and he dedicated himself to defense work when the capital was besieged by the Prussians. On this occasion, he incidentally used the iconometric method he had developed 20 years earlier to observe enemy positions. In 1871, following the defeat of France, after the peace treaties had established the annexation of Alsace and the Moselle by Germany, Laussedat was sent on a mission to negotiate the detailed position of the border. This mission made him famous and the patriotic efforts he made to save as many municipalities as possible in this rich mining region, earned him the recognition of the French people. He became a colonel and dedicated the following decade to more classical military engineering work, particularly in the field of transmissions (optical telegraphy, carrier pigeons, etc.).

Laussedat then returned to higher education: he was the director of education at the École Polytechnique (1879-1881), then the director of the Conservatoire national des arts et métiers (1881-1900) where he was already a professor. In 1894 he became a member of the French Academy of Sciences.

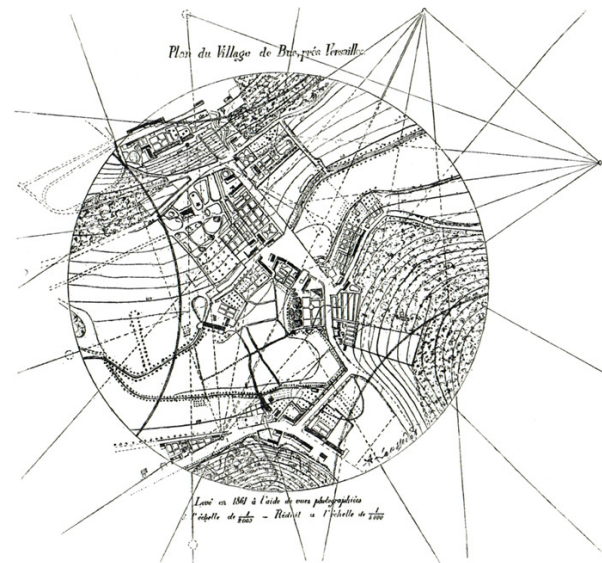
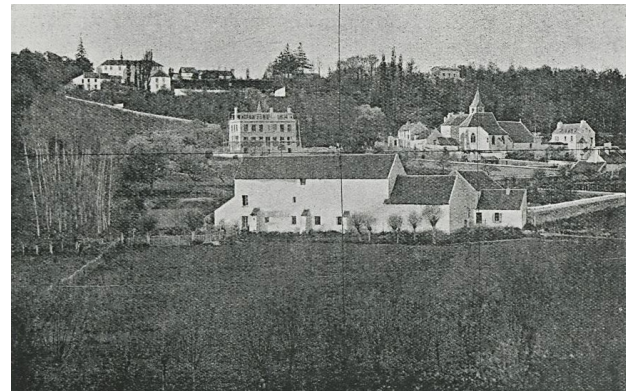


Figure 2. The Buc experiment : one of the images (above) and the map obtained by methophotography (below)

Until the last years of his life, Laussedat remained very active with honorary positions in several academic institutions, while pursuing a very prolific publication activity under the aegis of the Academy of Sciences. He even chaired the Paris Observatory Council a week before his death in 1907.

3. ROLE IN THE PRIMITIVE HISTORY OF PHOTOGRAMMETRY: CONTEXT AND INFLUENCES

Laussedat is often credited as being the father of photogrammetry. Indeed, his first attempt to use photographs for topographic survey was clearly a precursor approach that contributed to the emergence of photogrammetry a few decades later. However, the nature and the importance of his contribution were influenced by prior innovations that appeared in the previous generation. More over, the historical context in which he lived limited his own influence and the legacy he could transfer to the next generation, giving way to other inventors who deserve to share the recognition of the international photogrammetric community.

3.1 The influence of precursors

The intellectual context in which Laussedat entered the scene in the middle of the 19th century began to take shape during the Renaissance. From the middle of the 15th century, Portuguese navigators began to push the boundaries of the known world, Gutenberg introduced into Europe the mobile printing press

which was to facilitate the dissemination of knowledge, and the decline of feudalism invited to rethink the question of land administration. Several essential conceptual innovations appeared in the following decades, such as heliocentrism, analytical geometry and the birth of modern astronomy enabled by Galileo's telescope. The science of perspective, which is the basis of Laussedat's method of measuring an object through its image, also dates back to the Renaissance, with the remarkable contributions of Brunelleschi, Alberti and Dürer.

During the period 1820-1840 many inventions took place in the context of the industrial revolution, some of which having a connection with Laussedat's work: the development of non-Euclidean geometries allows a formalism more suited to geodesy; the development of least squares algorithms makes it possible to efficiently manage measurement errors; the electric telegraph incidentally makes it possible to synchronize distant astronomical observations and thus to improve the accuracy of longitudes; and the most noticeable invention of this period was photography, when Nicéphore Niepce managed to fix images in a dark room. Although Laussedat was far from taking inspiration from all this rich legacy, he paid great attention to a few scientific figures and two of them predominate and can be seen as his precursors: the amiral Charles-François Beautemps-Beaupré (1766-1854) and the great astronomer François Arago (1786-1853).

As early as 1793, the French hydrographer Beautemps-Beaupré, responsible for carrying out coastal surveys in the Solomon Islands (western Pacific Ocean), used hand-drawn views obtained from several positions of a ship, and on which he reported the angles between some remarkable points, measured with a reflection circle (Beautemps-Beaupré 1811).

Arago was the director of the Paris Observatory when Laussedat, then a student, met him in 1839. He soon understood the potential of photography, and he convinced the French government to buy the daguerreotype patent to "make it gift to the whole world". He presented a report at the Chamber of Deputies, on July 3, 1839, in which he listed the possible applications of photography: "We could, for example, talk about some ideas that we had on the rapid means of investigation that a topographer can obtain from photography. Everyone will think of the great advantage we might have gained, during the expedition to Egypt, from such an accurate and prompt means of reproduction. [...] To copy the millions and millions of hieroglyphs that cover, even outside, the large monuments of Thebes, Memphis, Karnak, etc., it would take legions of designers about twenty years. With the daguerreotype, one man could complete this immense work" (Arago 1839).

3.2 The circumstances in which the idea arose

Laussedat's interest for perspective views probably benefited from the circumstances of his particular work, consisting in topographic surveys of mountainous terrains and manmade edifications, i.e. objects standing up in front of him. It is not certain that he would have spontaneously imagined this method if he had been responsible for making topographic surveys in plain regions, for which terrestrial photogrammetry has never been considered as a very efficient tool.

Locating topographic points in perspective views seems to have been a personal intuition of Laussedat around 1845, even before he discovered that Beautemps-Beaupré had implemented a

similar method in an operational context. This approach seemed viable to him because of his skills in geometry and his great interest in photography. However, photography was a very recent invention, it required a heavy and bulky equipment which was not easy to carry on the field, the angular aperture of the objectives was too narrow (around 30° or less) and exposure times were too long to allow images of sufficient quality. This is why Laussedat came up with the idea of using hand-drawn views. The convincing example of Beautemps-Beaupré obviously encouraged him in this way, but another circumstance must be mentioned here because it explains the confidence he had in this method.

Laussedat was an excellent designer, with solid artistic skills. When he studied at Moulins secondary school, he was a pupil of art teachers such as Claude-Henri Dufour and Félix Massard. The latter had himself been a pupil of David, the court painter of Napoleon. They taught him the theory and practice of perspective, as well as drawing landscape views, a particularly demanding exercise at a time when photography had not yet taken over to record travel memories. His drawing skills (which would later be so useful for representing instruments in his publications) probably encouraged him to apply Beautemps-Beaupré's method, and his geometry skills allowed him to identify the limitations of such a method and to propose improvements.

These particular circumstances should not be considered independently from the general characteristics of Laussedat's time, since the historical context is essential in the appearance of an innovation.

3.3 Historical context

Beyond the particular circumstances of Laussedat's life and professional trajectory, the historical context in which he lived clearly influenced his ideas and achievements, both in technological and political terms. Indeed, no invention emerges regardless of place and time.

When Lieutenant Laussedat began his career as a military engineer in the 1840s, the photography that had just been patented was not yet operational. If we compare his situation with that of Meydenbauer born only fifteen years later, the latter could use photography at a more advanced stage from the beginning of his career, while Laussedat had first to be satisfied with hand-drawn perspective views. However, Laussedat was not in the same situation as Beautemps-Beaupré, whose mission took place in the late 18th century. Indeed, Laussedat could benefit from a more recent invention, the camera lucida, which was patented by the British scientist William H. Wollaston in 1806. Therefore, Laussedat's contribution to the emergence of photogrammetry would have been different if he had been born earlier or later.

The place where he lived can also have influenced the orientation of his research. Paris was one of the few cities where he could find a booming industry, intense scientific dynamism and institutions such as an academy of sciences and an astronomical observatory. To cite only examples related to the subject that interests us, Paris was the birthplace of several decisive inventions such as the metric system and photography. And a few years later, the famous photographer Nadar was to fly over Paris in a balloon to take the very first aerial photo. Therefore, living in Paris was a very favorable circumstance.

Another aspect to take into account to explain Laussedat's role is the political context of his time. His youth and early career took place under the July monarchy, under the reign of King Louis Philippe 1st (1830-1848) dominated by a liberal bourgeoisie which favored industrial prosperity and colonial expansion. The advent of the Second Republic (1848) stimulated his enthusiasm and his desire to serve the country. His first feasibility demonstrations of iconometry date from 1850. With his republican convictions, he did not accept the coup d'état of December 2, 1851, by the future emperor Napoleon III. No longer wishing to serve the French army, he resigned, but the Minister of War, general Vaillant, appreciated Laussedat whom he had supervised at the fort of Romainville a few years earlier, and he refused his resignation. By appointing him to the École Polytechnique, he allowed him to dedicate himself full time to teaching and research. It was during this period that Laussedat left the camera lucida and began his experiments with photography. He obtained from the army a daguerreotype and its accessories, and the army was officially witness to the experiment of Buc (near Versailles), which constitutes the first authentic implementation of photogrammetry.

However, Laussedat stayed away from military affairs, which explains why he never exceeded the rank of colonel. Even if the army authorized and even funded his research, he did not receive official support and his method, which was supposed to modernize topographic practices, was not used in France for official mapping between the 20th century. Besides he had the same difficulties in the field of geodesy: he tried to promote the participation of France in large international triangulations, but the empire neglected these opportunities and the French geodesy was considerably weakened.

In 1870, when war was declared, he was visiting the astronomer Warren de la Rue in London. He rushed back to Paris to make himself available to the French army. He used the telemetrograph - an improvement to the camera lucida he had developed 20 years earlier - to observe the plan of attack of the Prussian army. It was the very last use he personally made of his inventions, and the war marked the end of his research. He dedicated to following decade to more classical military engineering work, until he returned to the academic world to finish his career.

3.4 Laussedat's network: the seed of the international photogrammetric community

The originality of Laussedat's work drew the attention of foreign observers, and although he regretted that his inventions were not used in France, he had the satisfaction of seeing them used and even improved abroad (Polidori & Heipke 2019). His first efforts to promote photogrammetry abroad were in Spain, where his memoir on the Buc experiment was translated by his friend Carlos Ibáñez e Ibáñez de Ibero, like him captain in the corps of engineers, whom he had helped in the new triangulation of the kingdom of Spain (Soler & Mario Ruiz-Morale 2006). Later, his publications continued to be translated into different languages and his pioneering work became known in several countries, notably in Germany where the young architect Albrecht Meydenbauer had already developed the photogrammetric method for cultural heritage recording, unaware that the French officer had preceded him until he discovered the translation of his work (Girard 1865). The two men who met at Paris World's Fair in 1867, had similar destinies, except that Meydenbauer had strong support from the

authorities in his country while Laussedat had no support on the French side.

At the end of his life, an important part of Laussedat's publications consisted in observing the uses made abroad of his invention. He pointed to the pioneering work of Porro in Italy and Meydenbauer in Germany, who improved the photo-theodolite for the surveys for which they were responsible. Laussedat never forgot to note the support that his foreign colleagues received from their respective governments, while the French army continued to ignore his method. He also cited the works carried out using the photographic method for drawing up maps over large areas in distant countries, notably Thiele in Russia (Laussedat 1900) and Deville in Canada (Laussedat 1899a).

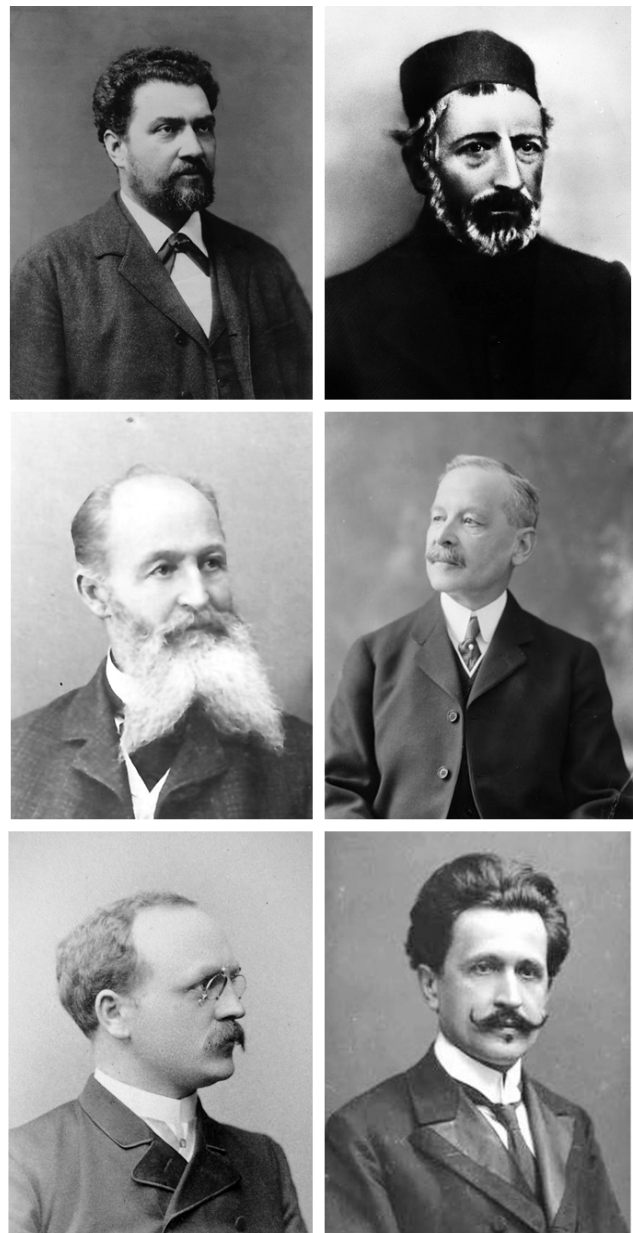


Figure 3. Seed of the international photogrammetric community: from left to right and from top to bottom, A. Meydenbauer (1834-1921), I. Porro (1801-1875), R. Thiele, G.-E. Deville (1849-1924), C. Pulfrich (1858-1927), E. Dolezal (1862-1955)

However, in all of these works, the theoretical principles of Laussedat's method could not be implemented in a very effective way for a large cartographic production. This stimulated the search for instruments capable of implementing both the principles of perspective and stereoscopic vision, making it possible to locate intersections for a large number of visible points in the images. Laussedat witnessed these efforts, which culminated in Pulfrich's manufacturing of the first stereocomparator in 1901. At the start of the 20th century, the photogrammetric community organized itself under the impulse of the Austrian photogrammetrist Eduard Dolezal (Hiermanseder 2019). National societies were first created in Austria (1907) and in Germany (1911), then the International Society for Photogrammetry (ISP) held its first congress in Vienna in 1913 under the presidency of Dolezal. For several decades, the meetings of this organization will pay tribute to the pioneer of photogrammetry, Colonel Aimé Laussedat.

4. DISCUSSION ON LAUSSEDAT'S CONTRIBUTION

Even if Laussedat is clearly the author of the first photogrammetric experiment in 1861, we showed in the previous section that his action had been influenced by others before him, by the circumstances of his personal life and by the technological and political context of his time. We can then wonder about the true nature of his legacy to the international photogrammetric community.

4.1 The nature of Laussedat's contribution

Laussedat was mainly a military engineer rather than a genuine scientist. When he was a young lieutenant of the French army, he was in charge of engineering projects based on topographic surveys and he was aware of the operational requirements of his mission. All his subsequent research was conducted by this awareness and by the desire to serve his country by modernizing the engineering methods. His quest was not to increase scientific knowledge, but to achieve methods that would work and that the army could use under operational conditions.

For reasons that we have already seen above, Laussedat was unable to use photography in the first years of his career, and he chose to use the camera lucida to draw landscapes. It is worth noting that it has moved from iconometry to metrophotography without any significant change in the method. Besides, at the end of his life, Laussedat himself presents this transition as a breeze: "When photography had become easier to practice and the improvements made to the construction of objectives had eliminated the cause of the deformations which had greatly limited its use, substituting photographic views for the views drawn with the camera lucida took place quite naturally, without causing any essential modification to the method" (Laussedat 1899b). By unifying drawing and photography in a single conceptual approach, Laussedat foreshadowed the photogrammetry of the 2000s, which manipulates data from different sources in the same virtual space.

Another difficulty stimulated his engineering skills. The use of hand-drawn perspective views, as Beautemps-Beaupré had done, required artistic talents. Laussedat himself had these talents, but he could not rely on dozens of soldiers to implement such a method, which is why he modified the tool. He first used the camera lucida which allows a rigorous perspective geometry while offering a field of view much wider than photography, then he brought two innovations to obtain the telemetrograph:

system which keeps the position of the eye fixed, and a telescope that allows to see from afar.

Similarly, when photography became a little more viable, the French corps of engineers provided Laussedat with a daguerreotype and its accessories, and his main activity was the development of a phototheodolite. He could rely the French industry which had become very efficient during the Second Empire. To make the camera a genuine measuring instrument with a distortion-free lens, he worked with Parisian optical and mechanical companies, notably Bertaud and Brunner, respectively.

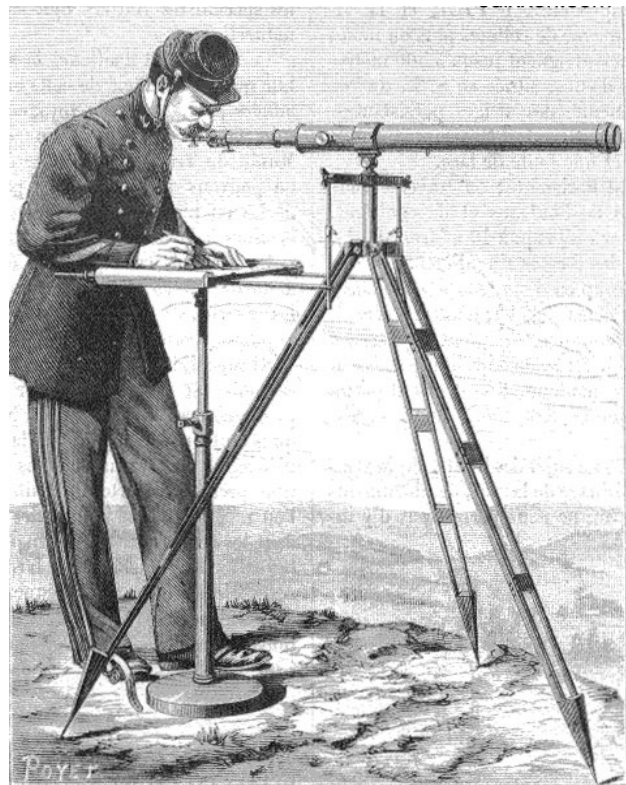


Figure 4. Laussedat's telemetrograph

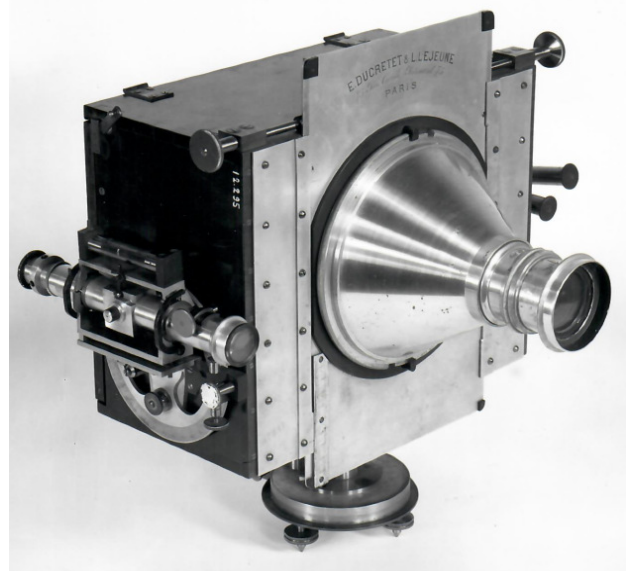


Figure 5. Laussedat's phototheodolite

Finally, from his earliest work, Laussedat dedicated himself essentially to instrumentation improvement. This was also the case with his research in geodesy and astronomy where his concerns were more instrumental than theoretical. This can be illustrated by two examples:

- when Laussedat took part in the new triangulation of Spain in 1858, he first invited Carlos Ibáñez in Paris where they designed the Spanish Standard – a length measurement device with unprecedented accuracy – with the Brunner company: this was his main contribution to the measurement of the triangulation base, while he does not seem to have played a major role in the dispute between French and German geodesists about the best length of triangulation bases ;
- when he conducted an expedition to Batna (Algeria) to observe a total solar eclipse in 1860, his actual contribution was to implement a photographic method to monitor to phenomenon: the interpretation of the data was done by astronomers like Faye, not by Laussedat.

4.2 The ideas he missed

Being the first to carry out topographic measurements in photographic images, Aimé Laussedat did not benefit from a professional community on this subject around him, and even if precursors like Beautemps-Beaupré and Arago suggested him the way to follow, he had to find solutions alone. If he had the merit of achieving his experiments successfully, it can be noted that some ideas, which seem obvious today, did not come to his mind. This is due to external obstacles such as technical difficulties, but also to what Bachelard (1938) calls the “epistemological obstacle”, placed by the mind between the researcher and the object of his research.

He claimed that his method had a universal scope, i.e. likely to be applied to all the situations that could be met in the cartography of the territory and in the military campaigns. However, in the first experiments, he used a single image to reconstruct a building, but his method then applied to objects that had particular and useful properties, such as vertical edges. This is contradictory with the aim of topography which is to reconstruct objects that we do not know. However, these hypotheses were not always explicit (Egels et al., 2019).

In addition, his surveys were impacted by measurement errors, notably related to the impossibility of knowing the horizon line and to the fact of constructing vanishing lines from very short segments like edges of roofs. He was aware of these errors but he evoked them in very general terms, without looking for quantitative solutions that could have taken advantage of algebraic methods. Methods like least squares adjustment, which have proven to be very useful in astronomy, had been invented before Laussedat’s birth and one can think that he had the mathematical background to understand them. He always ignored this approach.

Furthermore, if we compare the metrophotography implemented by Laussedat in the 1860s with the photogrammetry of the 1900s, we can note at least two essential ideas which were to become common in the 20th century but which Laussedat did not have, whereas they were already available: stereoscopy and aerial photography.

- The first stereoscopes were on sale in London in the 1840s and Laussedat, who was passionate about photography, probably knew about them. Hence, one can be surprised that he did not see the potential of this invention to look for homologous points between photographs. But it was an

entertainment, and as a military officer Laussedat must have thought that his job was too serious to use a toy that amused the Parisian bourgeoisie on Sunday after lunch. On the other hand, the fact that he first used hand-drawn perspective views, with lines and points, accustomed him to look for lines and points in all images. This approach was to continue when he used photography, and to deprive him of the intuitive reading of photography in which one can also describe surfaces. Laussedat was aware of this limitation. However, he never had the idea of using stereoscopy to overcome this difficulty, and it was only at the end of his life that he became aware of the potential of this approach, seeing that others had this idea that he had missed. “For some time, [...] somewhat everywhere, in France, in Canada, at the Cape of Good Hope, in Germany, we’ve noticed that stereoscopy could powerfully help metrophotography by relieving it from most geometric operations. What may have directed the minds towards this solution which mainly consists in greatly reducing the bases, is on the one hand, the extreme delicacy and the increasing precision of photographic images, and on the other hand, the mind satisfaction caused by the sensation of relief when the two images are arranged in an appropriate stereoscope”.

- When Nadar, photographer and aeronaut, acquired the first aerial photograph over Paris in 1858, Laussedat was then in the most active phase of his research in metrophotography (the Buc experiment was carried out in 1861). The military engineer closely followed the exploits of the famous photographer, who was a close friend of his, but he did not try to make use of aerial images. It is all the more surprising that Nadar himself suggested using them to produce cadastral maps (Nadar 1864). When aerial photography developed using balloons and then kites, Laussedat had already stopped his research, but he showed that his method could apply identically to photographs acquired from aerial stations. He noted, however, that the positions of the stations could not be linked to each other by distance and angle measurements like in terrestrial photogrammetry. It was an obvious limitation to the application of his method, but error calculation was not his strong point and he then simply waited for further progress of the instrumentation: “such a simple method obviously depends on the precision of the data which the improvement of the recording instruments will make more and more accurate; I believe it is called upon to render great service to the art of reconnaissance” (Laussedat 1890).

4.3 A poor lonesome photogrammetrist

Although Laussedat was inspired by the ideas of illustrious predecessors such as Beautemps-Beaupré or Arago, he believed in the possibilities of photography for mapping even before this technique was operational, and he is clearly the first to have demonstrated its feasibility in the presence of witnesses from the Academy of Sciences and the Army. Half a century later, he was still trying to promote his invention in his country where the authorities in charge of official cartography had always ignored it. We can guess that a more enthusiastic interest of the French government in Laussedat’s method would have created opportunities for him to play a more important role in the developments of modern photogrammetry and in the organization of an international community around him.

He was delighted to see his method used in private initiatives (such as the mapping of the Mont-Blanc Massif by Henri and Joseph Vallot, see Lagarde-Fouquet 2016) and abroad. In the 1900s, he remained a very attentive observer of the development of photogrammetry in the world. His publications

report on it for the French authorities, and show that even if he was very open minded and eager to share his inventions, he was on the other hand extremely offensive if, by any chance, his authorship was contested or ignored.

Henri Roussilhe, who became a full professor of photogrammetry at the Conservatoire national des arts et métiers (Paris) in 1937, evoked in his inaugural lesson the personality of his famous predecessor : "It has sometimes been said that he had a bad temper: the truth is that he was welcoming to all ideas and to all men, but sharp in language as well as in spirit, and severe in his judgements for all those who use their time and their energy to criticize, to envy, to disregard conscientious and selfless work".



Figure 6. Laussedat and his wife in 1902

5. CONCLUSION

Laussedat's contribution to the emergence of photogrammetry has been exposed and discussed. We have considered the nature of the influences he received and the legacy he passed on to following generations. We have shown that the technological and political context of his time had been favorable to some contributions but had prevented others. Finally, Laussedat was born 20 years too early under a regime which did not support him, but he was able to lay the foundations on which others built photogrammetry.

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Revised March 2020