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## Chapter 9

# Pedro Paulet: The Architect of the World's First Liquid-Fueled Rocket\*

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### Abstract

The first practical working liquid propellant rocket engine and spacecraft was invented and designed by Pedro E. Paulet, a Peruvian polymath, as a result of more than eighteen years of studies and practice among Peru, Germany, France, Great Britain and Belgium (1884–1902). He began experimenting with rockets since he was a child in Arequipa and developed his scientific studies at the San Vicente de Paul School, with his French teacher, Priest Hipólito Duhamel. Then, at sixteen, he entered San Agustín University (1890–1893) and studied science and art. He loved Chemistry and prepared many experiments in those years. At the same time, he practiced sculpture, drawing and painting at the “Artistic Center” (1891–1894), a cultural centre where he was the treasurer (1892–1893) and the librarian (1893–1894). In 1894, he tried to get into San Marcos University to study Medicine, but could not continue due to administrative problems. In the same year, his mother died (27.6.1894) and he had to return to Arequipa. In January 1895, he received the Bachelor degree of Science (14.1.1895) and at the end of the year, he decided to travel alone to France to continue further studies. He did not receive any scholarship from the Peruvian government as

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many authors have claimed. In 1896 he visited Industrial exhibitions in Germany (Berlin Gewerbe Ausstellung) to increase his knowledge about engines. In 1897 in Paris he worked as a journalist and became a member of the Société pour la propagation des langues étrangères of France. He applied the same year to the Astronomical Society of France. One of his most important articles was one of 1895, when he described the sensational invention of the automobile. This new invention captured the attention of young Paulet and sparked the impulse to enter to study at the Institute of Applied Chemistry of the Faculty of Sciences of Paris University. Over there he analysed the steam engine, the electric motor and others. In the classes of his teacher Marcelin Berthelot, he learned about the strength of explosive materials. In those years, the aim of that time was finding a light engine with a lot of power. Paulet thought the solution was in rockets with constant injection of explosive materials (propellants). He designed and built the first liquid propellant rocket engine LPre (nitrogen peroxide: oxidizer + petroleum ether: fuel) approximately in 1898, according to Newton's third law. Berthelot recommended him to use the panclastitas of Turpin, a powerful explosive material. In 1899, he published an article where he explained his ideas.

Keywords: Liquid propellant rocket engine, nitrogen peroxide, Pedro E. Paulet, Spacecraft, Panclastitas, Rocket plane.

## I. Introduction

The space age is allowing the human species to truly expand their capabilities, knowledge and environments. With the benefits of this sublime era we were reconfiguring our mind and body to new and unusual scenarios. Without a doubt, we are immersed in an aerospace revolution that will soon lead us to redefine many of our obsolete paradigms. How far will we go with the advances in aerospace technology? For now, we have extended our habitat and we have built housing that is orbiting the land: The International Space Station (ISS).

Our species is very ambitious. On land, we first leave our homes and go out to hunt our food. Then, we hunt animals and gain speed, then create movement devices such as trains, bicycles to shorten distances with the car. Our contact with the sea started swimming and then, we built boats afloat and underwater (submarines). Then came the desire to dominate the space and cross the air, literature inspired us to create the balloon and so the ballooning era began. At the end of the 19th century the Peruvian newspaper *El Comercio* indicated that the main problem of aero-navigation should be focused on "finding a very light and powerful engine" [1]. We are sure Mr. Paulet read this and he also remembered his scientific readings he did earlier in Arequipa [2].

This is a story about the Peruvian engineer and architect Pedro Eleodoro Paulet Mostajo—a Peruvian polymath—who designed and invented the first Liquid propellant rocket engine (LPR<sub>e</sub>) around 1898 and who also drew the first spacecraft design between 1900–1902 (Avion Torpedo: System P). These works were the result of more than 18 years of work and studies among Peru, Germany, France, Great Britain and Belgium (1884–1902). We briefly present here our first chapter with the proper documentation to complement previous Paulet’s studies that some people doubted and we are going to present new information that supports the remarkable achievement of this Peruvian Chemist Pedro E. Paulet: rocket pioneer or as we called him: *The architect of the world’s first liquid propellant rocket engine*.

## II. Problem

The Peruvian engineer Pedro E. Paulet wrote a letter from Rome in which he said: “... the rocket plane project has been devised and studied by the undersigned THIRTY years ago, when I was a student at the Institute of Applied Chemistry at the University of Paris. Such a project of mine is therefore prior to the construction of modern airplanes ...” [3]. Ninety-one years have passed since the publication of this famous letter, in which an honest and sincere man shared with the world, the invention of his life. The achievement of Paulet was nothing more and nothing less than the starting of a “new era,” the era of Aerospace technology, a new era that allowed man—thanks to rockets—to reach outer space. Several authors have pronounced themselves on what Paulet wrote, many believed him and others consider that his affirmations were false. The present work aims to demonstrate with new and unique evidence that what Paulet said is true. We must continue to deepen the research on his life to understand how he arrived at that fascinating moment of the invention of the first liquid propellant rocket engine in the world.

### **Who considers that Paulet did not invent the rocket engine?**

After reviewing the vast and varied bibliography on the development of Astronautics and Rockets, I have been able to detect various authors, who each in their own way, have denied or doubted the authorship of the invention of the rocket engine by Mr. Paulet. To synthesize the present study I will focus on three of them. The first who doubted the invention of Paulet’s rocket engine was Frederick I. Ordway III, who presents a paper in the third *History of Astronautics Symposium* in Mar de Plata, Argentina in 1969 [4], where he concludes that in

the absence of evidence, we cannot consider Paulet as the pioneer of the rocket engine. A second author is John Clark who in his book of 1972 *Ignition. An informal history of liquid rocket propellants* [5] denied that Paulet was able to attain the achievement of testing a rocket engine. For Clark what Paulet mentioned was completely false because he did not show any evidence to support his position. Finally, a third writer is George Paul Sutton who in his famous book *Rocket Propulsion Elements* [6] in the first edition of 1949 makes the first reference to Paulet's claim, but did not validate it, and in the subsequent editions this important scientist does not mention Paulet anymore. The same author in his book of 2005 *History of Liquid Propellant Rocket Engine* [7] states that Paulet did not invent the rocket engine, because his claim in 1927 the letter contains an incomplete and unproven description. Something that we need to point out is that Paulet's experiments with his rocket engine were carried out in the Institute of Applied Chemistry in Paris, France.

### **Who considers Paulet as inventor of the rocket engine?**

The authors who, on the other hand, have pronounced themselves in favor of the authorship of Mr. Paulet as the inventor of the rocket engine are diverse and from different parts of the world. I will focus on quoting four: the first is Max Valier (1895–1930), who in his book in 1928 *Raketen Fahrt* or Rocket Travel [8] gives credit to Paulet and quotes the correct reference of Paulet's letter of 1927. A second author is Nikolai Rynin (1877–1942) who in his encyclopedia of 1929 *Interplanetary Flight and Communication* [9] in Volume N°2. No. 4 on Rockets said: “The Peruvian engineer Pedro E. Paulet invented a rocket whose description (in Spanish) appeared in Lima in ‘El Comercio’ on 7th October 1927.” A third key author is Alexander Scherschevsky who in his book of 1929 *Die rakete für fahrt und flug* or The Rocket for Transport and Flight [10] published the following: “The first historical scientific experiments with rocket motors, and with liquid fuels, were carried out as early as 1895 to 1897 by the Peruvian chemical engineer Pedro E. Paulet.” Finally, in the famous book of 1966 *History of Rocketry and Space Travel* [11] written by Wernher von Braun and Frederik I. Ordway III, the authors indicated that thanks to the quote made by Scherschevsky it was possible to hear about Paulet for the first time and that is why he began to be recognized as the pioneer of liquid propellant rockets, but unfortunately they said “Paulet died in 1945 without his findings being validated.”

We must remember that since the third decade of the twentieth century many authors of different nationalities have made efforts to verify the authorship of Paulet as inventor of the liquid propellant rocket engine. In the Peruvian case

the enthusiasm has been diverse, books, newspaper articles, scientific journal articles, documentaries, etc. have been published, but the vast majority has not been able to find the respective evidences. It is important to mention two praiseworthy efforts, the first is Alvaro Mejia, who summarized his work in the essay: “Pedro Paulet: Multidisciplinary sage” [12] where Alvaro Mejia made two important quotes about the magazine *Die Rakete* on March 15th, 1928 and also by Robert Lademann who gives credit to the French magazine *Science et Vie* N°170 August 1931 where they give credit for Paulet’s work. The second is Luis Rojas—a Peruvian rocket engineer— has been developing a work also referred to the history of the rocket engine and has been able to conclude that the oxidizer peroxide of azoe used by Mr. Paulet, comes to be the same nitrogen peroxide or nitrogen tetroxide which is still being used in rocket engines. Mr. Luis Rojas concludes that in Astronautical literature Mr. Paulet would be the first to speak about the use of nitrogen peroxide as an oxidant for rocket engines.

### III. Solution

In 1944 Pedro Paulet said:

“... every technician aware of the history of inventions and discoveries, knows that the project does not consist in equalizing the processes of nature, but in overcoming them ... It would be necessary to study, not ‘aviation’ but ‘desgravitación,’ tending more than aeronautics, to the one aptly named by M. Rosny, ‘ASTRONAUTICS,’ that is, transport above the planet, where there is almost no air, no clouds, no ice.” Pedro E. Paulet [13]

With this message Paulet invited us also to enter to his perspective of studying things in a holistic and integrative way. In order to understand Paulet’s creative process and how he arrived at the invention of the rocket, we first approached all the people who studied the subject. Then we set out to review the vast majority of publications that have been made so far.

Now, in our first phase of research, we came to the conclusion that Mr. Paulet—as a journalist—was one of those people who used to publish regularly. Therefore, our first concern was to review the newspapers and the journals archives. This is how we began a patient process of thorough review that has lasted more than a decade in different libraries. We also consider investigating the production of colleagues, friends and institutions related to Mr. Paulet.

The results that we have obtained were worthy because we have located five new sources that prove that Mr. Paulet speaks himself of his invention, indicates characteristics and reflects on the importance of this topic.

## IV. Results

Arequipa is one of the main cities of Peru. Since its foundation on August 15th, 1540, it has had a great economic prosperity and a great connection with European culture due to its strategic position of its port, which for a long time was the obligatory route of the ships that arrived from Europe to Peru. Therefore, Arequipa was a multilingual city from its beginnings, where Spanish, German, English, French and Italian were mixed with Latin, Greek and Spanish. The Chili River crosses the city a few blocks from the main square. A series of volcanoes are near the city: El Misti, Pichu Pichu and Chachani.

Pedro Eleodoro Paulet Mostajo was born in this city on July 2nd, 1874, in a very humble family. He lost his father at early age. A few years later, Paulet had to live with the traumatic experience of the “Pacific war” with Chile (1879–1883). The war was a catastrophe for Peru because Chilean’s destroyed everything in their path, institutions, libraries, homes, cities, and especially the educational and cultural spirit. The city of Paulet, Arequipa, is a city that is next to volcanoes and practically the city is made with sillar, the volcanic lava. On the other hand, the people of Arequipa have a passionate habit of using fireworks for their parties, religious events and important celebrations. Paulet immersed in that cultural context also learned to love, make and practice with fireworks. But for some reason Paulet’s imagination went a little further, since he used to build bigger rockets and send animals to the sky to test the effects in the flight of the animals. He was a young dreamer and a practical boy who wanted to play and satisfy his aerospace curiosity.

After the war, the patriots began the process of regeneration and reconstruction. Fortunately, the destiny allowed the arrival of Father Hipólito Duhamel [14], who in 1880 became the Director of the Daughters of Charity of Arequipa and on August 30th, 1883 he founded the Free School of San Vicente de Paul. Duhamel implemented a pedagogy of integration of science and art. He commandeered from Europe new literary and scientific materials, geographical maps, a physics cabinet and a chemistry laboratory, etc. Paulet was an active student who knew how to take advantage of all this pedagogical material. Paulet was intrigued by the fireworks in Arequipa that later in his adolescence began to carry out several experiments outside the city. The students of Father Duhamel always stood out and proved to be well prepared, because many graduates later became important personalities of Peruvian culture. Paulet was one of the most outstanding students of the *San Vicente de Paul School*. Being well prepared due to luck and with only sixteen years—not the official age to study at the university—he was submitted to the admission exam of the San Agustín University (UNSA) in



which he was accepted with congratulations. Paulet studied at the UNSA from 1890 to 1893. By reviewing the courses, we have detected a strong passion for chemistry and physics. It is important to mention that Paulet had the pleasant coincidence of arriving at the UNSA when the institution renewed all the teaching materials with advanced equipment brought from Europe—thanks to the teacher's salary and work.

Paulet continued experimenting with his amateur fireworks (rockets) during this early years, but he decided to practice further away from the city for safety reasons. At the same time that he was a university student, he participated as the treasurer (1892–1893) and the librarian (1893–1894) at the Artistic Center, the first school of fine arts established in Arequipa. In 1894 Paulet came to Lima city (the capital of Peru) and applied to study medicine at San Marcos University, but unfortunately he was rejected for not knowing the entry requirements of Greek and Latin languages [15]. There is also another version that indicates that San Marcos did not validate his 3 years of science studies at UNSA. In the end, the result was that Paulet could not continue the study of Medicine and returned to Arequipa city to take care of his mother Antonina.

Unfortunately, months later Antonina Mostajo died (26.6.1894) and he remained completely alone. The following year, in 1895, he obtained the bachelor's degree in Sciences (14.1.1895). In July 1895 and being 21 years old—the official age to be an adult citizen in Peru at that time—he made plans to travel to Europe to follow in the footsteps of those scientists he had read with such passion at school and university.

There are some possibilities that the Goyeneche family or the Lopez de Romaña family supported him. We still do not know how successfully Paulet travelled to Europe, but what we have been able to detect is his activity the following year.

We must mention that the year 1895 was a very complicated year for Peru due to internal revolutions like that took place in Arequipa, and Paulet did not hesitate to become a member of the Peruvian Red Cross and, with childhood friends like Luis Villanueva, became part of the emergency ambulance corps in Arequipa.

Everything indicates that Paulet emigrated from Peru in mid-1895 and decided to take further studies to continue cultivating his passion for chemistry and rockets. We have found private letters where Paulet himself indicates that by October 1896 he was in Europe and visited the great industrial exhibition of Berlin: The Große Berliner Gewerbeausstellung [16]. This important event allowed Paulet to deepen his theory of air navigation, chemistry and other matters. From

youth, Paulet revealed a multifaceted personality, following the tradition of the famous Peruvian polymath Mariano Melgar.

For the year 1897, Paulet joined two French academic institutions: The Société pour la propagation des langues étrangères of France (The Society for the Propagation of Foreign Languages of France) and to The Astronomical Society of France (the first Peruvian in this institution) [17]. In the former, he developed and perfected the languages he had already learned in his school: French, German and English. And in the latter, he deepened the concepts of air-navigation and with the guidance of his mentor Camille Flamarion, he managed to further expand his scientific knowledge and imagination.

In 1895, Paulet became one of the first Peruvians to witness the development of the automobile. In one of his articles he wrote the following:

“14 years ago sent from Paris to this same newspaper (El Comercio) an enthusiastic news about motorsport, the great novelty then in Europe and in it said that ‘given the fever with which it had welcomed the new mode of locomotion success would be a matter of 10 years, I did not think I was such a good prophet.’” Pedro Paulet [18].

The innovation of the automobile drove him to study the engines and to enter to the Institute of Applied Chemistry of the faculty of sciences of Paris University, an institution that was created in November 1896 [19]. In this Institute he had excellent teachers, his best influence and mentor was Marcelin Berthelot, who advised him with his rocket engine project [20].

The studies lasted three years, the first year analysis and preparation of minerals, the second organic chemistry and the third industrial applications.

We have found that a few years later, Paulet himself revealed in *La Prensa* newspaper in 1910, details of his work and when he started the project of the liquid propellant rocket engine.

“I’ve been taking care of airlift since about 15 years ago (1895), and I certainly regret that I did not continue on the route that started me then. Abandoning the systems already classified as ‘heavier’ and ‘lighter’ than the air and remembering what I confess, the **pyrotechnic games of Arequipa** (Peru), acquired the convection that the air navigation could be solved and raised in the air a ship, of appropriately, by means of mobile batteries and combining them with rockets to continuous action, that is to say metallic rockets, in which by means of a kind of electric spark plug placed in the bottom, as in the cylinders of benzine engines, it could be made to explode intermittently an explosive gases. At that time I was studying at the Institute of Applied Chemistry in Paris and my director Friedel and the wise Berthelot found the idea very interesting. Thanks to Berthelot’s advice, I was able to find the desired explosive mixture, but as far as the rocket was concerned, I did not find any steel that could resist more than 200 explosions with a useful effect, asencional.” Pedro E. Paulet [21].

As we can see Paulet was very honest and indicates that all his curiosity was born emulating what he learned in his childhood in Arequipa (Peru), years later in 1927—in his famous letter—he reaffirmed what he said in 1910.

“The project of the rocket plane has been devised and studied by the one signed 30 years ago (1897) when I was a student at the Institute of Applied Chemistry at the Paris University. Such a project of mine is therefore prior to the construction of modern airplanes. ... My definitive experiences were made with vanadium steel rockets, -then a novelty- and with the panclastites that Turpin, the author of the melinite, had just invented. .... preliminary experiences the rocket provided with outer rings of long flexible tubes that connected its mentioned conduits to the nitrogen peroxide and benzine deposits and a spark plug conductor to the power socket.... one rocket of 2.5 kilos, with 300 explosions per minute, gave 90 kg. of pressure.” Pedro E. Paulet [3].

The key to the invention of Paulet’s first liquid propellant rocket engine was due to his passion for chemistry from the school, the university of Arequipa and then the Institute of Applied Chemistry in Paris. But Paulet, a man of clear values also wrote something very sensitive about the invention of the rocket plane:

“Even though I do not know that someone has taken care of me before, the rocket plane, I do not intend to vindicate the paternity of this invention, because, like any project, it is worthy if not for its realization, the inventor of the rocket plane will be the first to manage to fly on a rocket-powered device.” Pedro E. Paulet [3].

What Paulet did was a mankind achievement of the human mind that manages to connect different branches of knowledge to arrive at a multi and inter disciplinary work. He was aware that aviation was about to change humanity in the 20th century. In 1909 he joined the Aero Club of France and promoted air navigation with different activities and articles. In one of them he showed his enthusiasm about how to beat gravity with technology:

“Air navigation has more ambitious sights. Disdaining not only the floor but any support that binds it, uses as a broad path the atmosphere, the immense transparent fluid that envelops the world and in whose depth we move with the unconsciousness of organisms that are shaking in the depths of the sea. To the utilization of the earth and water, as a way of communication, then the air that covers both is prepared. Now, what is the first obstacle, which then must be overcome, the action of gravity? and is that an insurmountable obstacle? Do not!” Paulet [18].

And of course, being clear about the effectiveness of its rocket motor. He does not hesitate to promote astronautics in 1944 with his LPRé and his System P (Rocket plane). He was very connected with all the trends and main authors of the field as we can see in this text:

“I do not think there is more progress in aerial locomotion imitating the flight of birds... what is to be studied, not ‘aviation’ but ‘desgravitation.’ Extending more than aeronautics to the well-known one by M. Rosny, the ‘astronautique,’ that is the transport above the planet, where there is almost no air, no clouds, no ice. It imposes a new form of mobile, which should not be aerodynamic but astronautics.” Pedro Paulet [13].

What Paulet managed to do was adapt the technology of the motors of the cars and give a plus with his knowledge of pyrotechnic, rockets and chemistry. Paulet informed in his writings that he had to try many chemical formulas to get at the appropriate one. He concludes that for its rocket motor it should be optimal to use liquid and non-solid propellants. The formula that he chose was the mix of peroxide of azoe or nitrogen peroxide (oxidizer) and petroleum ether (fuel).

For the year 1899, knowing that the Universal Exhibition of Paris was closer, Paulet managed his participation in being hired by the Peruvian government as a delegate responsible for the stand of the department of Amazonas. His time in this mega exhibition allowed him to expand his design and applications.

In the original sketches that are kept in the Museum of the Peruvian Air Force—thanks to Megan Paulet—we can see his Industrial Revolving Engine (Girandula) that he designed in 1900 and the scale drawings of his Rocket Plane. Designs that he managed to finish in 1902 in the city of Antwerp, Belgium. A curious fact stands out when I reviewed the original drawings, you can find some traces of German writing behind English writing that proves the German influence Paulet had. Something that reinforces this connection is the fact that he studied at the Technische Hochschule of Berlin in 1902. Moreover, in the article “The Automobile” I found out that Paulet learned from Daimler’s engine that future aircraft could work both in the air and in the ocean [22]. Finally, those ideas mentioned above were used in his LPR.

Then in 1901, Paulet was invited by the Peruvian government to study wireless telegraphy, technology that would be ideal for his rocket plane project.

And from 1902 to 1904, he was hired by the Peruvian government to work in the consulate of Antwerp, Belgium where he continued to deepen his technical knowledge.

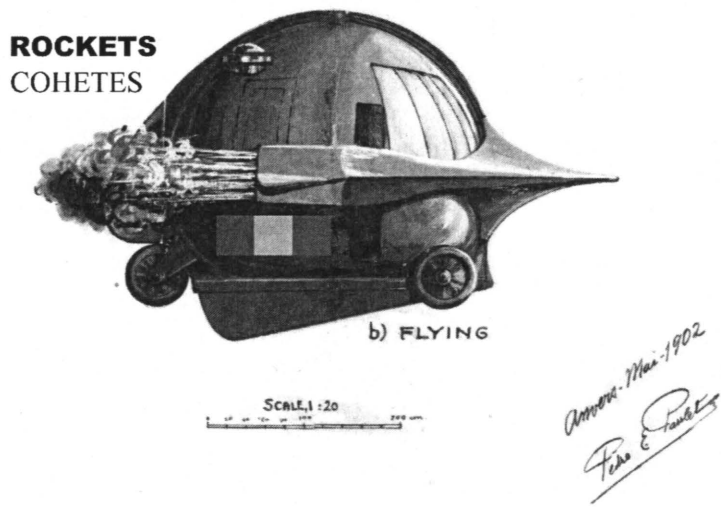
Much remains to be investigated in relation to the invention of Paulet’s Liquid propellant rocket engine. We hope in the near future we will be able to find new sources in the archives of Germany, United Kingdom, France and Belgium to know more about this interesting topic.

## V. Conclusions

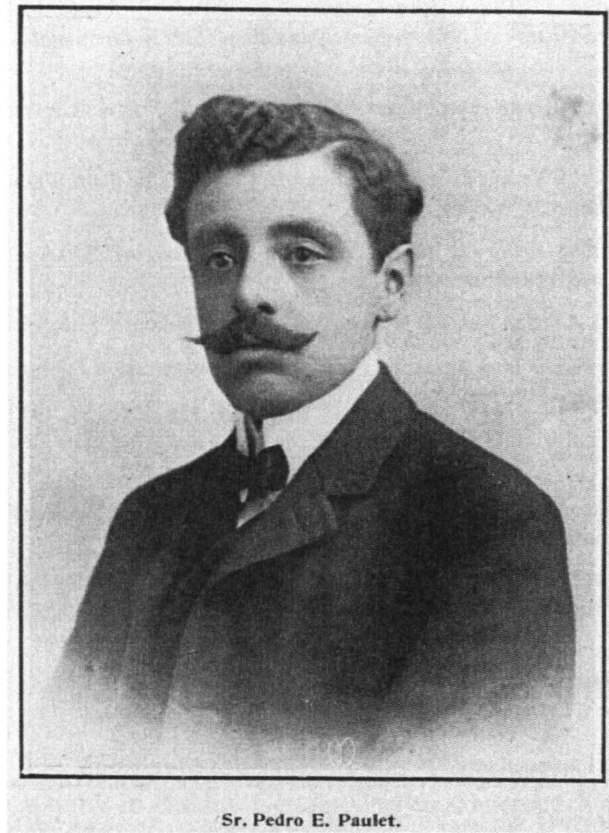
1. Paulet's passion for rockets was born in the city of Arequipa due to the cultural context, the characteristics of the city and the influence of its members in the school, the university and the associations he belonged to and participated in.
2. The systematic study of Chemistry from the school and university in Arequipa and in the European institutions were the key for Paulet to reach the appropriate mixture of ad-hoc fuel for its Liquid propellant rocket engine.
3. The desire to study, to participate in exhibitions and conferences allowed him to expand his knowledge from his native land Peru and in all the countries (Germany, France, Great Britain, Belgium) where he worked and lived.
4. The active participation of Mr. Paulet helped him to increase his technical abilities. We found evidence of his visits at: a) 1896 Industrial exhibition of Berlin (Berlin Gewerbe Ausstellung 1896), b) 1898–1899 The first and second International Automobile exposition in France, c) 1900 The Universal Exhibition of Paris in 1900 where he participated as the official delegate of the Peruvian government. He was in charge of the stand of Amazonas department. This event really helped him to developing new ideas for his rocket engine and his rocket plane. d) Industrial Dusseldorf Exposition of 1902.
5. The liquid propellant rocket engine (LPR<sub>e</sub>)—ideal engine for the development of Astronautics—was invented, designed and tested by Mr. Pedro E. Paulet, a specialist in chemistry, who also delineated “The torpedo plane” (Spacecraft prototype). This feat was the result of more than 18 years of work and studies between Peru, Germany, France, Great Britain and Belgium (1884–1902).
6. As a scientist and as a technologist, he managed to design and build the first liquid propellant rocket engine LRPe using peroxide of azoe or nitrogen peroxide (oxidizer) and petroleum ether (fuel) at the end of the XIXth century, thanks to his intelligence, audacity, perseverance, prudence, will and courage.
7. Paulet's liquid propellant rocket engine was invented and tested between 1898 and 1899, and also in 1901 he continued working in the project because we found a private letter of Mr. Paulet signed in 1927 where he explicitly thanks his mentor Mr. Berthelot for encouraging him in the use of war explosives to solve air navigation.

8. Paulet's actions and achievements were the result of an open mind that he learned from several scientific institutions. During 1888–1911 we have detected that he had membership of approximately more than 15 institutions.
9. The new 5 sources that we have found wrote by Mr. Paulet himself about The car (1895), The automobile (*El Tiempo* 23.8.1899), Something about aviation (*El Comercio* 3.10.1909), the private letter about Berthelot (Rome 9.2.1927 MREE) and the extraordinary Paulet's interview (*La Prensa* 18.9.1910) where he gave lots of details about his rocket plane project and his LPre gave us strong evidence to support his claims.

**AVION-TORPEDO**  
 SYSTEM PAULET  
 (1902)



**Figure 9–1:** Avión Torpedo or Auto Bólido (Spacecraft prototype) with LPre. Final project signed in Antwerp, Belgium in May 1902.



**Figure 9-2:** Chemist Pedro Eleodoro Paulet Mostajo,  
Lima, Perú 1906 Prisma magazine Nº16

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