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Chapter 2

Victor Coissac: A Forgotten Astronautical Pioneer and Contemporary of Konstantin Tsiolkovsky, Robert H. Goddard and Robert Esnault-Pelterie*

Jacques Villain,† Frank H. Winter‡ and Frederick I. Ordway, III**

Background

The science of astronautics was born in the late 19th and early 20th centuries. Four great pioneers would lay the theoretical foundations: Konstantin Tsiolkovsky of Russia, Robert H. Goddard of the United States, Hermann Oberth of German heritage, and Robert Esnault-Pelterie of France. During the second half of the century, their theories would be put into practice, leading to the conquest of space. Other scientists and engineers of the period, although less well known, also sought to contribute to the knowledge of astronautics, for example Fridrikh Tsander and Yuri Kondratyuk in the Soviet Union. Another one of the earlier investigators is perhaps worthy of attention and is almost totally absent in the literature. This is Victor Coissac, a Frenchman who began his writings on space

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travel as early as 1915 with the first, privately published version of *La Conquête de l'espace* (*The Conquest of Space*), followed by a 1916 edition appearing as two different books bound in one volume. The first is *L'évolution des mondes* (*The Evolution of Worlds*) while the second is *La Conquête* (hereafter cited as *The Conquest of Space*.) This was about the same period that Tsiolkovsky, Goddard, and Esnault-Pelterie were actively working out their theories, and almost a decade before Oberth's classic book, *Die Rakete zu den Planetenräumen* (*The Rocket into Planetary Space*), was published in 1923, though Oberth had begun to lay out his theories at about the time Coissac's work first appeared.

In fact, Tsiolkovsky's only published work on the subject was his 1903 article "Ilsseldovanie mirovykh prostranstv reaktivnymi priorami" ("The Exploration of Space by Reactive Devices"), which also appeared in 1914 as a 16-page pamphlet, while Goddard's first published paper on rocketry was *A Method of Reaching Extreme Altitudes* (printed in 1919 and released in 1920). Esnault-Pelterie's lectures on spaceflight in Paris, in November 1912, were published shortly after in condensed form in the *Journal de Physique* in March 1913. There also appeared Yakov Perelman's *Mezhplanetnyye Puteshestiyya* (*Interplanetary Travels*), a popularization of Tsiolkovsky's works. It therefore appears that Coissac's *The Conquest of Space* was perhaps the first book-length exposition of spaceflight in the West.

Thus, at the outset, three important questions arise: whether the recognized pioneers cited above were familiar with Coissac's work; whether he was familiar with their contributions; and whether his own work was scientifically valid. The question of why Coissac's name and *The Conquest of Space* have generally escaped the literature after all these years is more problematical. It may, in part, be tied in with how scientifically valid he was, but most likely had more to do with the probable limited circulation of *Conquest*, the association of the author with unpopular political beliefs, and his secluded lifestyle.

Golotyuk, in his article cited in the bibliography, claims that the early Soviet spaceflight pioneer Yuri Vasilyevich Kondratyuk (real name A. I. Shargei) apparently may have obtained the idea from Coissac of the "orbital technique" of landing on planetary bodies, given in his (Kondratyuk's [Shargei's] book *Azvoevanie mezhplanetnykh prostranstv* (*The Conquest of Planetary Space*), written between 1916–1925 and published in 1929, but this claim requires closer study and may be taken up in a possible Part 2 of this article. For certain, the authors have found Coissac's name and title of his *Conquest* in Alexandre Ananoff's comprehensive *L'Astronautique* (*Astronautics*) (1950, page 429), only in passing, and otherwise it appears to be practically lacking in the literature.

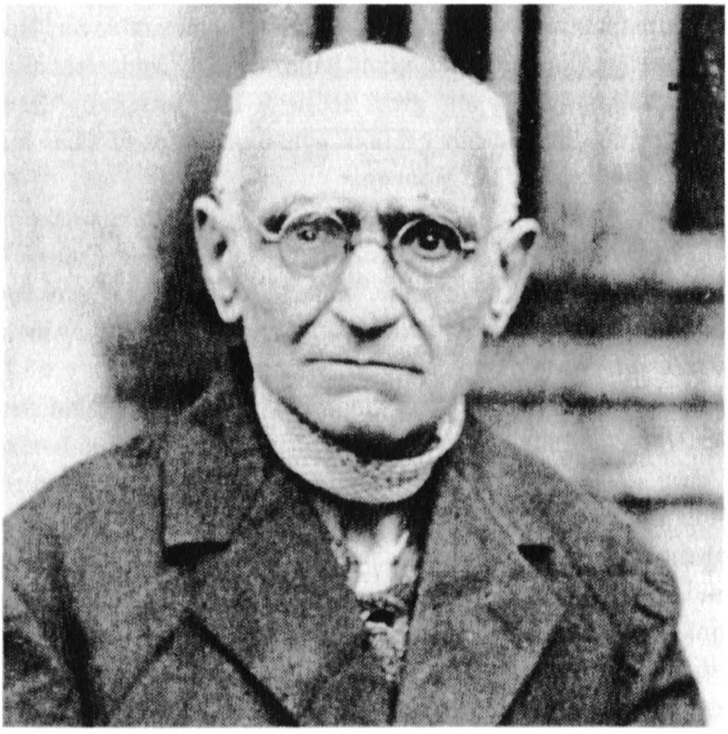

Figure 1: A photograph of Victor Coissac (1867–1941), taken in December 1940, just months before his death (Photo: Courtesy of Editions Champ-Vallon, Seyssel, France).

At this point, we can judge that Coissac was not known to the main pioneers cited above, nor vice versa. Regarding his validity, Coissac's work was more intuitive than scientific. A prime example is that the technology behind his rocket is not really justified mathematically and is contrary to the known laws of physics that explain reaction propulsion. In addition, he makes a number of rash assumptions: the virtual absence of atmospheric drag, a highly unrealistic mass ratio, little temperature rise on atmospheric reentry, and many others. This empirical approach places him firmly on the fictional side of science. Thus, in no way does he rival the true scientific pioneers of astronautics mentioned above.

However, it is remarkable enough that a still largely unknown serious book-length work on the possibilities of spaceflight should appear that early and written completely independently of the great pioneers. Moreover Coissac's book, including the so-called second edition of *Conquest*, printed in 1925, contains some interesting, although not necessarily original, concepts for the time, namely lateral thrust control, staged rockets, atmospheric braking, the use of hydrogen/oxygen combustion to produce water (the principle of the modern fuel cell), a solar mirror for propulsion, a module that separates from the main rocket to explore the planets, and a kind of rudimentary planetary rover. He also speculates on interstellar flight. On the other hand, he only addresses these issues in general terms without going into great depth. A later article by the authors may attempt to determine, among other things, actual priorities of ideas found in Coissac compared with those of the pioneers.

Thus, while Victor Coissac is clearly not in the ranks of the pioneers, his work is still worth looking at for several reasons. Foremost, Coissac's book may be the first serious exposition on the subject in the West. Second, the authors have the opportunity to fill in a historical gap and "introduce" or include Coissac as a bona fide serious thinker on spaceflight and contemporary of Tsiolkovsky, Goddard, and Esnault-Pelterie, even though he was a kind of "missing link" between Jules Verne and the pioneers. His thinking is, in fact, more of an extension of Jules Verne's—a name frequently mentioned in his book—than related to the works of the pioneers. Overall, we gain a wider and hitherto hidden range of astronautical thought during this early period, a greater appreciation of what the pioneers did accomplish, and a close look at a highly colorful, if not always scientific, thinker.

As to the question of whether the pioneers may have purposely overlooked Coissac's work because they may have considered it not entirely valid, this is highly speculative, and again, there are aspects to it that are valid. By the same token, it may be speculated that had the pioneers known about the work, they may have welcomed this contribution in a field that was brand new, and one in which almost no literature existed. Coissac's *The Conquest of Space* was as much a starting point as any. Once more, the available evidence is that the work was simply not circulated, even in France. Today, it is exceedingly scarce; only a handful of copies are known to exist throughout the world.

It should also be noted here, that the foregoing article is based largely on the "second edition" (actually, the third) of Coissac's *The Conquest of Space*, since that edition was the only one available to the authors when we first conducted this study and its date of publication of 1925 was not known to us. Nonetheless the authors have since acquired the original 1915 and 1916 editions and will more closely compare the differences, if any, between all three.

Biographical Sketch of Coissac

Victor Coissac was born in Treignac, in the Correze Department of France, on 3 May 1867. His father, Jean-Baptiste, was a tailor. He and his six brothers and sisters were raised as Catholics, though Coissac became an atheist.

V. COISSAC

Ancien Membre de la Société astronomique de France,
Président de la section France-Ouest de l'Alliance scientifique universelle

LA CONQUÊTE DE L'ESPACE

EXPOSÉ DES MOYENS

QUE PEUT FOURNIR LA SCIENCE ACTUELLE

POUR RÉALISER DES VOYAGES

AUX DIFFÉRENTES PLANÈTES

DU SYSTÈME SOLAIRE

DEUXIÈME ÉDITION

REVUE ET AUGMENTÉE

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Groupe Morelly, à Puch (Lot-et-Garonne)

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Figure 2: Title page, Coissac's *La Conquête de l'Espace* (*The Conquest of Space*), the so-called second edition, published by the Librairie de l'Intégrale, at Puch d'Agenais, 1925. The First edition was published in 1916 by L'Intégrale.

At 14, Victor was sent to Paris to learn his father's trade. However, he was more drawn by the capital's intellectual life and began to study on his own. Within six months, he had earned a school certificate. By 1889, at 22, he held a teaching post in the city of Tours. Three years later he married Adele Berthon. Although it was not a happy marriage, they still had several children.

Victor Coissac was hungry for knowledge and seemed to be interested in everything, especially in new scientific discoveries. He was a member of the Astronomical Society of France and presented several papers. He was also president of the western France section of the Universal Scientific Alliance.

Not exactly modest, he believed that if his theories did not meet with the expected approval, it was because his ideas were ahead of their time. In particular, he developed a theory of gravitation. However, he was not really satisfied with this theory, because it still relied on the existence of God—and he wanted to prove that God really did not exist. In fact he was rather surprised that the illustrious Camille Flammarion, author of *La Pluralité des mondes habités* (*Plurality of Worlds*) and *Le Monde avant la création de l'homme* (*The World before the Creation of Man*) believed in an immortal soul.

Starting in 1905, Coissac became involved in politics as a member of the new United Socialist Party. By the following year, he was talking about the need to change the world and of only relying on a few people to accomplish this goal. He founded the *Bulletin de l'Union Populaire* (*Bulletin of the Popular Union*), which he would write himself, by hand.

In other words, Coissac took a keen interest in many areas. Above all, he was an idealist and utopian, with an amazing degree of optimism. However, judging from his own writings, it is not always easy to say if he was a sincere believer in Utopia.

Coissac was also an anarchist and a pacifist. Encouraged by the interest in his ideas expressed by the new anarchist members of the Popular Union, around 1910 he organized a meeting to found an association he called l'Intégrale (The Integral). He recruited ten members. The founding of this association was announced in the *Journal Officiel* (*Official Journal*) on 6 January 1911. He started a new publication, the *Education Review*, with articles on education, philosophy, and art. What he would call the Intégrale's "Tours Establishment" would primarily operate a printing business to mainly print his many esoteric works. In 1921, he added a small linen production shop, but this closed after several months.

His private life was not going well either, and he and his wife separated. The following year he decided to take Intégrale a step further. He and his supporters purchased a farm in Puch d'Agenais, not far from Toulouse. They started a small "pacifist community dedicated to work and friendship," where people could live and work the land together and develop Utopia. On 3 July 1925, the young Suzanne Le Boudec came to the community. Three years later, she gave birth to Victor Coissac's son. Coissac also came to found several other reviews at Puch, including *Libre Pensée Intégrale* (*The Integrale Freethinker*) and a *Bulletin* in addition to *Stories and Anecdotes* in 1930.

In all, some 70 men and women lived in the community during a period of 13 years. They were not always well regarded by their neighbors, who were suspicious of their utopian ideas and especially their atheism. Their suspicion was also exacerbated by the fact that Coissac was considered a bit mad.

By the early 1930s, their finances were in bad shape, in large part because they had to rely on loans and donations—contrary to their professed autonomy and utopianism. To turn things around, Coissac was counting on the publication of a 310-page book titled *l'Envol* (*Taking Off*), written by a friend named Charles Rouch and edited by Coissac. Published in 1934 under the pen names Lesly and Illidé, it was a modernized version of Verne's classic *From the Earth to the Moon*, or rather a fictional version of *The Conquest*, but the book was a total failure. Its subscription attracted only 18 persons. Nonetheless, it is of interest to note that in the foreword of *l'Envol* is cited the name of H. G. Wells, the noted British science fiction author and historian. More intriguing, it is explained that the Soviet Union would send money to the organizers of a Moon trip (fictional or real is not clear), in addition to delegates, including a prestigious scientist. If this was real, could the scientist have been Tsiolkovsky, who was then still alive (he died the following year, in 1935)? We may never know.

In any event, the financial situation of Coissac's community worsened. Rouch promised another three manuscripts, *Le Crime* (*The Crime*), *Sur la Lune* (*On the Moon*) and *Eux quatre* (*Four Themselves*). Rouch too was a fellow space travel thinker as at the end of *Sur la Lune* he announced another work, titled *Le village spatial* (*The Space Village*), but this may not have been produced. In any case, Coissac had a falling out with Rouch and thought it was a safer bet to write something himself. Using the pen name Marcel Illidé, he wrote *L'Education sexuelle en dix leçons* (*Sexual Education in Ten Lessons*) and a 471-page risqué novel, *Lucette*. Deemed outrageous for the times, this book was probably the reason that Coissac was imprisoned from 1936 to 1939. The only book (of the three planned) to actually be published was *On the Moon*, printed by Intégrale in February 1935 and credited to Illidé (Coissac) and Lesly (Rouch).

The experiment was coming to an end. By December 1934, the Intégrale community was nearly bankrupt, with debts of 500,000 francs and heavily mortgaged. The farm was sold in late 1935, 13 years after the start of the community. Victor Coissac, Suzanne, and their son, all left Puch for the Department of Gers.

Here they would live for nine months in the town of Cassens, near Condom. In the spring of 1936, they moved a few kilometers away to the village of Grazimis, where Coissac, now 69 and still convinced he was right, created a new community, l'Idéale. It would never attract more than four members, but once again Coissac started a printing business for financial support and to spread his ideas.

The declaration of war in 1939 was a tremendous shock to his idealistic tendencies. Worn out, sick, and deeply disappointed, he died on 7 March 1941 of a heart attack. Buried in the Grazimis cemetery, his tomb bears an inscription placed there by Suzanne: "Here lies Victor Coissac, who passed away on March 7, 1941 at the age of 74, Pray for him." As Diana Cooper-Richet and Jacqueline Pluet-Despatin wrote in their biography of Coissac, *L'Exercice du bonheur où comment Victor Coissac cultiva l'utopie entre les deux guerres dans sa communauté de l'Intégrale* (*The Exercise of Happiness or How Victor Coissac Cultivated Utopia between the Two Wars in His Community of the Intégrale*) (Seyssel: Ed. Champ Vallon, 1985), this was indeed "a curious epitaph for Victor Coissac, an ardent freethinker his whole life." Most of the preceding biographical sketch of Coissac comes from the same work by Cooper-Richet and Pluet-Despatin.

Victor Coissac's Utopia and Other Works

Victor Coissac wrote books on a wide range of subjects, covering philosophy, science, education, and sociology. Before founding the Intégraliste movement, he had already published several books, mainly by himself:

1898: *Enseignement Primaire. cours élémentaire—Enseignement méthodique de l'orthographe* (*Primary Education. Elementary Course—Methodical Teaching of Spelling*) (Paris: Delalain Frères).

1901: *Enseignement Primaire. cours moyen—Enseignement méthodique de l'orthographe en harmonie avec l'arrêté du 26 février 1901 sur la réforme de l'orthographe* (*Primary Education. Middle Course—Methodical Teaching of Spelling in Compliance with the Decree of 26 February 1901 on Spelling Reform*) (Paris: Delalain Frères).

1903: *La nature et des secrets* (*Nature and Her Secrets*).

1905: *Les Manifestations de l'énergie* (*Manifestations of Energy*) (Tours: by the author).

1913: *Dieu devant la science et devant la raison. étude critique sur les religions, les systèmes Philosophiques et les Prétendues Preuves de l'existence de Dieu* (*The Place Supposed Proofs of the Existence of God*) (Tours: by the author).

1915: *La Conquête de l'Espace* (*The Conquest of Space*) (Tours: by the author). See also 1916, *L'évolution des mondes,* below, and 1925, *La Conquête de l 'Espace*).

1916: *La réalisation du bonheur* (*Achieving Happiness*) (Tours: by the author).

1919: *L'art de faire fortune par un enrichi* (*The Art of Getting Rich by a Newly Enriched*) (Tours: by the author).

The bookshop of his utopian community L'Intégrale also published several of his books, both in Tours and in Puch d'Agenais:

1914: *Les Erreurs de la science contemporaine suivi de Illusions* (*Errors of Contemporary Science followed by Illusions*) (Tours).

1916: *La morale sans Dieu. exposé des vrais principes qui doivent servir de base à faire le bien*, first edition (*Morals without God—An Essay on the True Principles which Should be Used to Establish Rational Moral Guidelines and the Real Motives for Man to do Good*).

1916: *L'évolution des mondes suivi de la Conquête de l'Espace* (*The Evolution of Worlds followed by The Conquest of Space*) [two books in one volume]. Considered as the first edition of *The Conquest of Space*, but according to the Catalogue Général de la Libraire Française (Paris: Libraire Ancienne Edouard Champion, 1924), T. 28, page 124, Coissac published *La Conquête de l'Espace* first in Tours, "chez l'auteur" ("by the author") and it contained 250 pages.

1921: *L'évolution des mondes—Exposé des grandes lois gui régissent l'univers et du Processus qu'elles déterminent. Terminé Par une appréciation de la théorie d'Einstein* (*The Evolution of Worlds—Expose of the Great Laws which Govern the Universe and of the Process, which Determines Them, Ending with an Appreciation of the Theory of Einstein*, 2nd edition (Tours: Libraire de L'Intégrale).

1922–1923[?]: *Le mariage. le ménage et l'éducation des enfants. Conseils aux jeunes gens par un Père de famille* (*Marriage. Housekeeping and the Education of Children. Advice for Young People from a Father*).

1924 [?]: *L'histoire impartiale de la IIIè Républigue* (*An Impartial History of the Third Republic*), two volumes.

[1925]: *La Conquête de l'Espace exposé des moyens que peut fournir la science actuelle pour réaliser des voyages aux différentes planètes du système solaire* (*The Conquest of Space, Account of the Means of Being Able to Furnish Actual Science for Realizing Voyages to the Different Planets of the Solar System*) (Puch), 147 pages.

1934: Published under the pen names Illidé [Coissac] and Lesly [Charles Rouch], *L'Envol* (*Taking Off*), a fictional version of *The Conquest*, (Puch d'Agenais).

1934: Published under the pen names Illidé [Coissac] and Lesly [Rouch], *Sur la Lune* (*On the Moon*) (Puch: L'Intégrale).

Other works, undated, or of uncertain dates, are:

Les entretiens de Maître Barthélémy: lst part: L'univers peut s'expliquer sans faire intervenir l'idée de Dieu: 2nd part: Dieu n'existe pas (*Interviews with Master Barthelemy: 1st Part: The Universe Can be Explained without Using the Concept of God; 2nd part: God Does Not Exist*).

Législation générale et économie sociale (*General Legislation and Social Economy*).

L'être vivant. son origine. sa destinée (*Human Beings. Their Origin and Fate*).

Réforme de l'outillage intellectuel de l'humanité (*Reforming Humanity's Intellectual Tools*). Published under the pen name of Marcel [Illidé], (Lucette, 1930s novel), 471 pages.

As suggested by the titles of the majority of his books, Coissac was an idealist, an innocent who wanted to reform society. In fact he expressed the thoughts of many people, during the two world wars, who were searching for Utopia. As he wrote: "Publications by The Intégral are neither Bolshevist nor anti-Bolshevist, but rather communal. The Intégral aims to accomplish a social revolution peacefully, step by step. Its action, while still minimal, will rapidly pick up speed, so that the world revolution will come within a century, provided that the revolutionary actions by libertarians, Communists, Socialists, etc. have not succeeded in the meantime."

It is tempting to speculate how *The Conquest of Space* fit within his philosophy. This would take more study beyond the present article but offhand it fit comfortably within Coissac's idealistic aspirations for the progress of humankind and was also an extension of his personal interests in astronomy and science. On the other hand, it is astounding that even by the time of the so-called second edition of this work, or 1925, he appears still to have been unaware of both Goddard's 1919 *Method of Reaching Extreme Altitudes*, Oberth's 1923 *Die Rakete zu den Planetenräumen*, and even the published 1913 paper by his own countryman Esnault-Pelterie. Perhaps this was because he then resided on his communal farm in Puch d'Agenais and in effect was paradoxically cut off from several developments he should have known about. It is also possible that the accomplishments in the spaceflight literature of both Goddard and Oberth, and Esnault-Pelterie also, had not penetrated into that part of (southern) France as yet. As for Tsiolkovsky, he was then scarcely known even in his own country of Russia because, much like Coissac, he largely published his works out of his own pocket and they therefore saw limited distribution outside his own rural Kaluga. It was only much later, in the 1930s, that Tsiolkovsky's works came to be known in the West.

Coissac's Theories on the Conquest of Space

In general, Coissac believed that communications (voyages) among the different planets of the solar system would be "audacious and costly, but not impossible." The study of these possibilities was the aim of Coissac's first edition of *Conquest* (1916, and possibly the original 1915 edition also). The aim of the "second" and "augmented" edition" (1925) was to present "a review of the resources offered by current science to travel to different planets of the solar system." In fact, since the second edition seems to reprise most of the first edition, the summary below is based on the second edition. Coissac's own chapter headings are followed, along with a short review of the most pertinent points in each chapter. The bracketed numbers following each or most of the paragraphs are the pagination from the second edition.

Foreword

Coissac says, at the outset, that the time has come [1915–1916] to conquer space because "right now, it is perhaps less difficult for man to launch himself, under full control, that it was to produce airplanes and balloons, or to reach the poles of our planet...It seems to me that our current state of scientific knowledge is sufficiently advanced to discover practical means of communication, if not with other star systems, then at least with most planets, satellites and comets in our own." According to Coissac, interplanetary voyages would require "much less monetary sacrifice than for the discovery of Earth's poles...which also took many lives, lost forever to science. The conquest of space is much more certain, and will require far less sacrifice...As for the cost, it will scarcely exceed that of a railway of comparable distance." [9–10]

Chapter 1: General Prerequisites

Space trips will take several months or even years, which means that travelers will have to be given comfortable accommodations. Coissac first addresses the question of the temperature. "The cold of space will not be a hindrance for voyages that do not go beyond the orbit of Mars." Beyond that, he deems it necessary to have a heating system inside the vessel, which would also be equipped with a thermal protection system. This heater would be surrounded by wood, along with a wood-air mattress covered with polished metal. "The best heating method would undoubtedly be a pure oxyhydric gas generated by the combustion of hydrogen and oxygen. This is an interesting method because the combustion also produces water." He estimates that for a six-year voyage, the vessel will have to carry nine tons of gas. [13]

For the cabin air supply, Coissac proposes adsorbing carbonic gas by a potassium or sodium solution. For three voyagers, he calculates that 1,200 kilograms per year of sodium would be needed. Oxygen is supplied either by carrying it onboard, or by generating it from a reserve of potassium. In the first case, the vessel would need 615 kilograms per year, and in the second, 1,750 kilograms of potassium. The vessel would also have to carry 1,100 kilograms of water for drinking and other purposes, with the combustion of an oxyhydric gas providing additional oxygen. [21]

In short, Coissac believes the problems of onboard life will be easy to resolve. His mass budget for the first year of the trip is as follows:

Potassium chlorate	1,800 kg
Sodium	1,200 kg
Water and oxyhydric gas	3,000 kg
Provisions	2,000 kg
Furniture, books, instruments	4,000 kg
Voyagers and personal effects	300 kg
TOTAL	12,300 kg [23]

Concerning the vessel's interior, he indicates that "each voyager should have a personal cell measuring at least two by three meters; there should also be a common room with a library and instruments, measuring at least five by five meters, along with a walkway and storerooms." He adds: "In these calculations I assumed a spherical shape, but this would not be practical, and a parallel-piped form seems better." He sets the dimensions at nine by nine meters, from five to seven meters in height, and recommends steel and wood construction. The empty weight would be 12–15 tons, totaling 32–35 tons for a year-long voyage. [23]

He then addresses the question of how to impart a speed of 12 km/sec to this vessel, claiming that it is impossible and that he will demonstrate it. At this speed, it will take about two years to reach Mars, six years to reach Jupiter, and twelve years for Saturn. However, he does make a distinction between two types of voyages: "observation trips in which we will merely pass near the planet, without landing; and exploration trips, including a landing on the planet." In the latter case, "the planet in question has to offer resources allowing a return to Earth...I believe that observation trips could be made at least to Jupiter and exploration trips to all planets and all satellites which are neither bigger nor heavier than Earth—except of course where extreme dangers are involved. [This was, of course, before the discovery of the planet Pluto in 1930 and the later discovery of its moon]. The lack of air, [and] presence of mountains or cliffs, would not be obstacles. Extreme temperatures are not likely on small planets, and even on Mercury, we could protect ourselves from the blazing Sun. But it would be a folly to land on planets where there is a corrosive atmosphere, ferocious inhabitants who are better armed and organized, or where the ground is not firm." [25, 27]

Chapter 2: Propulsion

Considering that all problems concerning the space vessel have been resolved, in the second chapter Coissac reviews the launch method; that is, how to impart a speed up to 16,000 meters/sec. [31]

Examining Jules Verne's idea of a huge cannon, he decided that it is "absolutely impracticable" because of the huge initial acceleration that would make it unbearable for voyagers. He considers a second method: a large steel wheel, at least 500 meters in diameter and weighing 1,000 tons, that would act like a slingshot. "One merely has to set it spinning at ten to twelve revolutions per minute. In less than half an hour, after a thousand to two thousand revolutions, we would achieve the necessary speed...but could human beings stand the whirling of this wheel?" He thinks it unlikely, leading to a third solution: "a rocket, capable of flying in the air and even in vacuum." Since he believes that a rocket moves forward because of its exhaust gases pressing against the air, he wonders how it will advance in a vacuum. Coissac's answer is: "in a vacuum, the rocket could push against (assuming it needs support) the first gases ejected." In other words, Victor Coissac does not really understand how a rocket works. [31–34]

He also raises the idea of increasing the combustion pressure—estimated at 0.8 bar—by "obstructing the exhaust of the gases." From his point of view, the gas speed, which he considers analogous to the rocket speed, is proportional to the square root of the combustion pressure! He estimates the mass of his rocket at 250 tons if the pressure is increased to 1.4 bar, compared with a theoretical 40,000 tons at 0.8 bar! But Coissac's reasoning goes even further. "Assume that we can place a huge sack around our machine, stretching several leagues in every direction, with virtually no mass and in which the gases will escape. It is obvious that nothing about the movement will change as long as the sack is not filled with gas. And if we could conceive of a method to condense these gases and recover them, we could use them ad infinitum." [37]

He considers an advantageous ration between the masses of the spacecraft and the rocket to be about one thousand. This gives a total rocket mass of 40,000 tons—"which is not excessive"—and is broken down as follows: vessel: 40 tons, rocket structure: 500 tons (for a structural ratio of 1.3 percent), and propellant: 39,460 tons. [37]

This gives a velocity at the end of combustion of 4,200 meters/sec., which he deems insufficient. In Coissac's calculations, the 40,000 tons of solid propellant could be contained in a cylinder 20 meters in diameter and 130 meters long. However, it would be more effective from his viewpoint to build a large number of cylinders (stages), each one to be jettisoned after combustion is finished. According to his calculations, there could be up to 65 cylinders. But as he points out, "gunpowder is far from the best chemical compound...[and] guncotton [already suggested by Jules Verne] generates four times as much, without residue. If we use guncotton, we could quadruple our vehicle's speed to 16,800 meters/sec." This would exceed actual requirements, which gives energy reserves for trajectory corrections, orbital injection, or landing on planets. "For a Moon trip lasting a month or two, the machine would only weigh 3,000 tons at the beginning." [37–38]

"The "launch pad" for this rocket would be a well dug in the ground and fitted with ramps. Coissac considers air resistance during the launch to be negligible. He also evokes the idea of building the exploration vehicle with materials recovered from the stages after combustion is finished—all during the trip, of course. The vehicle would be fitted with wheels, and could use "an engine similar to that powering our automobiles." [39]

Chapter 3: Lengths of the Voyages

In addition to a number of reflections on the lengths of space voyages, Coissac says, "The main method I am proposing, therefore, consists of launching tangentially to the Earth's orbit, in the same direction as the Earth, for trips to the outer planets, and in the opposite direction for the inner planets." [49]

Chapter 4: Changes in Plans and Trajectory Projections

Coissac fully realizes that during the trip there will have to be changes in plans and trajectory corrections. The answer is to simply impart "a lateral acceleration that would subsequently be cancelled by an acceleration in the opposite direction." [57–60]

Chapter 5: Launch Errors

"There could be three types of errors, concerning:

- the initial velocity
- the moment of departure
- the direction

"The voyagers would only realize this several minutes after departure by a very accurate observation of the terrestrial disk. They would have precalculated tables telling them at what time they should see the Earth at a given angle." [63]

Chapter 6: Orbital Displacement and Orbital Injection

In this chapter, Coissac addresses the question of how to place the vessel into orbit around the target planets. He also calculates the height of Earth's atmosphere. "I think," he says, "I can say with certainty that our atmosphere is surely over 700 and less than 1,000 kilometres high. But in practical terms, we have to admit that at 200 kilometres and above, the atmosphere is not dangerous for voyagers returning from space who want to temporarily place their vehicle into orbit."[75]

Chapter 7: Landing on Other Planets and Return to Earth

To land on other planets, the exploratory vessel would have to decouple from the main vessel once it is in orbit, and use the atmosphere to reduce its velocity; but it would also have to be fitted with a damping system to absorb the shock on impact. Coissac even plans for the space travelers to lie down in "drop boxes" before the impact; these are a sort of "padded box, internally formed to the exact shape of the body." In any case, he considers that there is no danger of the vessel burning up in the atmosphere. "All the live energy of the vehicle cannot be converted into heat, because most of it will be used to displace the air molecules." If extra energy is needed for propulsion in space, he will call on a solar motor, comprising a mirror 12 meters in diameter that would concentrate the Sun's heat on a boiler containing ethyl alcohol or toluene. "This liquid would vaporize and the vapour would flow through a flexible tube into a tank where it cools and condenses. The result is a steam jet very similar to that produced by the rocket, but not as powerful." [90]

Chapter 8: Planetary Exploration

Coissac wonders about the possibility of breathing on other planets: "I believe that in general, we would not be able to breathe on other planets. There is a great chance that either the proportion of free oxygen is too low, or too high, or that there is too much carbonic gas, or that the whole is mixed with other, toxic gases, such as chlorine, sulphuric gas, cyanogen, hypo-nitrous acid, etc. Atmospheres in which we can breath must be the exception. In fact, it is one of the reasons I believe that life is impossible on most planets. However, it will not prevent exploration [of the planet], if the temperature is bearable. If the atmosphere proves to be breathable, all the better: you open the door, go out and start to explore...Bicycles could be very useful...it would be possible to build an aeroplane with parts prepared in advance." [98]

Chapter 9: Voyage to the Moon

"The speed needed to reach the Moon, without shooting past, is 11,073 meters/sec." Here, Coissac is referring to Jules Verne's 1865 classic *From the Earth to the Moon.* He says that although Verne is a famous novelist, he is an inadequate astronomer and his book contains errors. [101] He then indicates how to land on the Moon. "By changing the speed, we can very easily adjust the orbital injection so that our vehicle revolves around the Moon in a circular orbit, nearly skimming over its highest mountains (seven kilometers from the seabed). We then choose our landing field (a plain as high as possible). At the right moment, we quickly decelerate and land on the Moon at a speed of less than 120 meters/sec. The shock will be hard, given the virtual absence of an atmosphere, but it can be tolerated because of the shock-absorbing device and the 'drop boxes'...Exploration can then be carried out as described above, using space suits and bicycles. The bicycle will be extremely useful on the Moon where gravity is one tenth that on Earth [*sic*]. You could travel 300 kilometres in ten hours and if the voyager runs into no major obstacles, he could travel around the Moon."[104]

Coissac estimates the cost of a voyage for a two-month stay at 2,520,000 francs (roughly U.S.$500,000 by today's values), or about a franc a kilometer. The total is broken down as follows:

- Studies and preliminary experiments: 200,000 francs
- Vehicles and furnishings: 200,000 francs
- 250 tons of nitric acid cellulose at 8 francs/kg.: 2,000,000 francs
- Three months of provisions for three voyagers: 20,000 francs
- Miscellaneous: 100,000 francs [105]

Chapter 10: The Vehicle and Its Contents

In this chapter, Coissac returns to the construction of the rocket and the space vessel. On reflection, he now decides that the shape of the vessel, whether spherical, cylindrical, or parallel-piped, is not important. "It should have four rooms: one for the engine and kitchen, one living room with library, a dining room and a bedroom, the latter divided into as many cells as there are voyagers....There should also be toilets and a junk room....The vehicle body will be made of sheet steel on a steel frame. I believe that steel is preferable. Aluminium is lighter, but to offer the same strength, it would have to be much thicker so that we would not save any weight, quite to the contrary. And it will not help on cost savings either, given the [then present] price of aluminium. The inside of the body should be covered with a second wall, made of planks of wood, that can be easily disassembled so that the voyagers could remove or replace them, depending on the outside temperature."[110]

The rocket itself would be made of several stages he calls "reservoirs of explosive powder which are simply stacked on top of each other." In his published diagram (his Figure 10), we can see five stages, but he says that there could be others, depending on the destination. This rocket is then installed "in a well at the peak of a high mountain to diminish air resistance." He considered Popocatepetl in Mexico. He specifies that the side thrust used to correct the rocket's trajectory will be provided by bleeding off some of the main propulsion gases through pipes. "For example, if we use nitrocellulose, we could simply allow the gases to escape through two holes facing in opposite directions and placed equidistant from the vehicle's centre of gravity, thereby producing torque in a direction opposite to the rotation."[113]

Nor does he forget the problem of disposing of onboard waste. "An opening will be provided in the floor of the vehicle to get rid of all types of waste...this opening will be fitted with a short, wide tube, hermetically sealed by a valve opening to the outside."[115]

Coissac then lists the objects that must be taken on a voyage of this sort:

- Inflatable rubber mattress
- Tables and chairs
- Provisions, potassium chlorate, sodium, etc.
- Oxygen apparatus and dissolution tank
- Paper, pens, pencils, compasses
- Science books and detailed medical books
- Novels and travel books
- Chess, checkers, dominoes

- Pharmacy [medicines]
- Repair tools
- Replacement glass for the portholes
- Liquid air reserves to replace losses
- Toiletries
- Pots, pans, dishes, silverware
- Brooms, feather duster
- Hydrogen tank for lighting and heating
- Incandescent gas mantle
- Solar mirror
- Precision clockwork chronometers
- Physics instruments: barometer, thermometer, etc.
- Electric battery to ignite the propellant
- Rotating signalling panels to show the rocket's location to voyagers who are off exploring the planet
- Astronomy instruments
- Cameras and plates
- Appropriate space suits
- Bicycles and folding canoe
- Gymnastics apparatus
- Double entry tables for navigation
- Weapons
- "Drop boxes" and drag chutes
- Money
- Signalling panels to communicate with the Earth [116–117]

Obviously, besides many other deficiencies and oddities in his list, Coissac did not consider weightlessness in space.

Chapter 11: Conclusion

"I believe," Coissac says confidently, "that I am entitled to conclude that the question of interplanetary voyages is now virtually resolved, and that it comes down to a question of money, lots of money. At the same time, I have demonstrated that these voyages involve minimal danger. There is, of course, the powder we are carrying, but if our vehicles as well constructed, this will not be a big danger. The hard landing on planets is indeed a thorny issue...but I've indicated methods of largely attenuating the shock...Or becoming the prey of the inhabitants of another planet. This is more serious danger."[121–123] extérieure et sortir. Il est inutile, je pense, de décrire l'opération contraire.

On disposera au-dessous du véhicule les réservoirs de composition fusante (fig. 10). Il y en aura plusieurs, simplement emboîtés les uns dans les autres, et chargés pour obtenir de chacun une vitesse donnée. De cette manière, lorsque l'un d'eux commencera

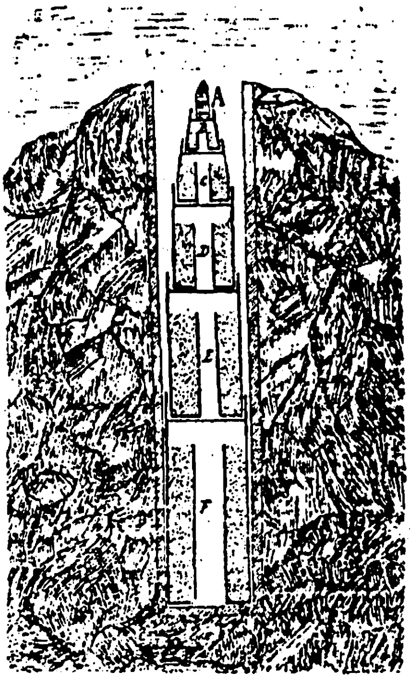

Fig. 10. — Les préparatifs du départ.

son action il n'aura pas à emporter ceux qui auront terminé la leur. Il n'y aura lieu de fixer (et encore pas très solidement) que les réservoirs qui ne devront pas être utilisés pour le premier départ.

Je dis : et pas très solidement, parce que, d'une part, rien ne viendra les séparer du véhicule. Même non fixés ils l'accompagneraient, ayant la même vitesse que lui, et se trouvant soumis aux mêmes influences gravifiques. L'assujettissement n'est qu'une simple mesure de précaution. D'autre part, il faut que les voya-

Figure 3: Multi-stage space vehicle, from Coissac's *La Conquête de l'espace* (*The Conquest of Space*).

— 51 —

par rapport à elle, et une vitesse de 39.700 mètres par rapport au Soleil. La vitesse à l'aphélie tomberait à 4.200 mètres.

4° Celle de 33 ans, dont je parle plutôt ici pour mémoire, par une vitesse initiale de 15.800 mètres, donnant, à toute distance de la Terre, une vitesse de 11.200 mètres par rapport à elle, et une vitesse de 40.700 mètres par rapport au Soleil. La vitesse à l'aphélie serait d'environ 2.060 mètres. Cette orbite serait presque tangente à celle d'Uranus.

5° L'orbite de 61 ans, indiquée aussi pour mémoire, par une vi-

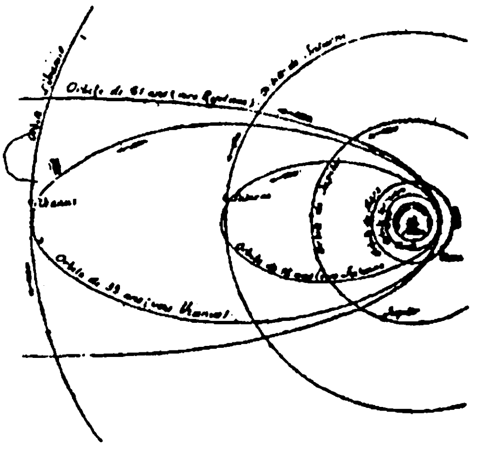

Fig. 4. — Orbites du véhicule pour Saturne, Uranus et Neptune (1).

tesse initiale de 16.200 mètres donnant, à toute distance de la Terre, une vitesse de 11.720 mètres par rapport à elle, et une vitesse de 41.250 mètres par rapport au Soleil. La vitesse à l'aphélie ne dépasserait pas 1.400 mètres et l'orbite en question serait, à très peu de chose près, tangente à l'orbite de Neptune.

Une vitesse initiale de 16.560 mètres se traduirait, à toute distance de la Terre, par une vitesse de 12.219 mètres par rapport à elle, c'est-à-dire par une vitesse totale de 41.719 mètres par rapport au Soleil, par conséquent parabolique par rapport à cet astre. Le véhicule, animé de cette vitesse de 16.560 mètres au départ de la Terre, partirait pour l'infini.

1. Grands axes de ces orbites, 398 et 750 millions de lieues.

Figure 4: Orbits of vehicles to the planets Saturn, Uranus, and Neptune, from *La Conquête de l'espace* (*The Conquest of Space*), typical of several orbits worked out by Coissac.

Interplanetary voyages open up a large field of potential positive discoveries, concludes Coissac. He does not end here, however. Probably influenced by his interest in astronomy, Coissac speculates on voyages beyond the solar system—interstellar missions—and in this respect, he was as farsighted a thinker and dreamer as the major astronautical pioneers of his time. "Will one ever be able to visit...far-away stars of various colours, or changing brightness, these nebulous gases, worlds in formation?" he ponders. "Will man be able to penetrate...the secrets of the infinite?" Then he thinks about the awesome light-year distances involved and how impossible this seems. Hypothetically, for an interstellar voyage he visualizes a space vehicle "large enough to contain several families along with animals, [and] plants able to reproduce themselves indefinitely, a sort of artificial celestial body that would encompass an entire village with housing, equipment, raw materials to renew them following wear and tear, plus several kilometers of fields, gardens, meadows, woods. "But," he concludes, "such an expedition very probably will never occur...given our current scientific knowledge." Coissac goes on to consider a mission to Alpha Centauri that might take six centuries outbound and as long for the return to Earth. He is clearly talking about generational space travel, a subject that would later be a favorite topic taken up by many science fiction writers. [122]

When Victor Coissac finally does end his discussion, he admits that it is "superfluous to worry about this subject" [interstellar flight] yet predicts that once the exploration of the solar system has been achieved, man " will be able to guess, by induction, the secrets of the more distant systems." [122–123]

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