

History of Rocketry and Astronautics

**Proceedings of the Forty-Fifth History Symposium of
the International Academy of Astronautics**

Cape Town, South Africa, 2011

Otfrid G. Liepack, Volume Editor

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AAS History Series, Volume 42

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 31

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AMERICAN ASTRONAUTICAL SOCIETY

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2014

ISSN 0730-3564

ISBN 978-0-87703-613-5 (Hard Cover)
ISBN 978-0-87703-614-2 (Soft Cover)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: <http://www.univelt.com>

Printed and Bound in the U.S.A.

Chapter 10

The Three Heroes of Spaceflight: The Rise of the Tsiolkovskii-Goddard-Oberth Interpretation and Its Current Validity*

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Abstract

The single most enduring interpretation in space history credits three thinkers with independently proving the scientific and technological feasibility of spaceflight in the late nineteenth and early twentieth centuries: Konstantin Tsiolkovskii in Russia and the USSR, Hermann Oberth in German-speaking Central Europe, and Robert Goddard in the United States. Precursors and contemporaries, such as Hermann Ganswindt and Robert Esnault-Pelterie, are usually assigned to a distinctly second rank. In recent years, the historian of Soviet spaceflight Asif Siddiqi has labeled this scheme a “cliché” and the Goddard biographer David Clary has called the interpretation a 1960s invention that “bears reexamination.”¹

While the Tsiolkovskii-Goddard-Oberth (TGO) interpretation had its origins in priority claims inside the international space advocacy movement be-

* Presented at the Forty-Fifth History Symposium of the International Academy of Astronautics, 3–7 October 2011, Cape Town, South Africa. Paper IAC-11.E4.3.01. A different version of this work was published as “The Three Heroes of Spaceflight: The Rise of the Tsiolkovskii-Goddard-Oberth Interpretation and its Current Validity,” *Quest: The History of Spaceflight Quarterly*, Vol. 19, No. 4 (2012): pp. 4–13.

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tween the 1920s and 1950s, this chapter traces its full-blown emergence, at least in the English-language literature, to the post-1957 “space race.” After the launch of Sputnik, the USSR trumpeted Tsiolkovskii’s founding role even more loudly than it had earlier, the United States adopted Goddard as its neglected hero, and the former Germans in the United States (notably Willy Ley and Wernher von Braun) testified as to Oberth’s influence. The interpretation hardened into a set pattern visible in most histories of spaceflight written by advocates and journalists, especially those in English.

In recent years, new scholarship has made the historical context for the early theorists and enthusiasts much richer, notably works by Siddiqi and James Andrews on Tsiolkovskii and the early Russian/Soviet spaceflight movement, and by Clary, J. D. Hunley, and Frank H. Winter on Goddard and his impact on rocket technology and the public imagination.² This new literature provides the basis for the reexamination of the validity of the “three heroes” scheme that Clary calls for, and not just an examination of its origins. It is my conclusion that, based on the theoretical originality of Tsiolkovskii, Goddard and Oberth, and their role in sparking the formation of space societies and stimulating other theorists to publish, the traditional interpretation still is defensible, but at the cost of ironing out many complexities, such as the intellectual foundations of the various space movements, and the contributions of other theorists like Robert Esnault-Pelterie, Walter Hohmann, Yurii Kondratiuk and Fridrikh Tsander.

The Origins of the Interpretation

Before an international spaceflight movement emerged between 1924 and 1933, there was a period of several decades in which isolated amateur and professional scientists, engineers and inventors tried to imagine how to create a feasible technology to solve the apparently utopian problem of travel to other celestial bodies. I cannot retell that complicated story here, although I will later discuss some of the priorities of the various writers and thinkers that shed light on whether the TGO interpretation is still defensible. Suffice it to say that the clear pattern is that there are two outliers who began as early as the 1880s to grasp the central insight, that a greatly improved rocket was the key to space travel (an idea much more obvious in hindsight than it was at the time). Both of them were marginal eccentrics—a near-deaf schoolteacher in Kaluga, Russia, Konstantin Tsiolkovskii, and a cranky inventor in Berlin, Germany, Hermann Ganswindt. But only the former went on to develop a scientifically sound body of theoretical work demonstrating space travel’s feasibility.

The majority pattern was the multiple independent discovery of the same set of ideas, or at least parts of them, between about 1908 and 1918, a quite common occurrence in the history of science and technology.³ For example, after several years of racking his brains, the American physics student Robert Goddard realized the rocket was the answer in early 1909, a year or so after French aviation pioneer Robert Esnault-Pelterie, and a year or so before the Transylvanian-German high-school student Hermann Oberth. But despite early articles by Tsiolkovskii (1903 and 1911–1913) and Esnault-Pelterie (1913), a Belgian patent on advanced rocket ideas issued to the French physician André Bing (1911), and an extremely obscure and flawed book by a French utopian socialist, Victor Coissac (1916), all of the pioneers operated in isolation, and several were convinced that they were the first in the world to think of these ideas. Goddard, for one, was obsessed with his supposed priority for the rest of his life. The few publications there were languished in obscurity, except in Russia, where the famous science journalist Iakov Perel'man published a book based on Tsiolkovskii's work, *Mezhplanetnoe puteshestvie* (*Interplanetary Travel*) in 1915, the world's first popular, nonfiction discussion of realistic spaceflight technologies. But a combination of the linguistic barrier between Russia and the West, the war, and the Revolution and Civil War, meant that this work was unknown outside Russia and soon mostly forgotten within it.



4- REF at the controls of the "REF-2 monoplane".

Figure 10–1: Robert Esnault-Pelterie. Credit: Smithsonian National Air and Space Museum (NASM A-3966-C).

The first work that made an international impact was Goddard's *A Method of Reaching Extreme Altitudes*, which the Smithsonian Institution published in early January 1920 with a 1919 date on it. Frank Winter has recently demonstrated that Goddard's proposal to hit the Moon with a rocket carrying flash powder, accidentally produced not just a newspaper flap in the United States, but

also a worldwide echo of media publicity, one that fundamentally reshaped science fiction and the popular understanding of spaceflight.⁴ Wild rumors that Goddard would soon launch himself to the Moon circulated around the globe in the 1920s, notably in Central Europe and Soviet Russia. The effect was such that the Austrian rocket experimenter Max Valier wrote in 1930 that “even today the broad mass of the public often mistakenly believes that [Goddard] was the first originator of the modern spaceflight idea.”⁵

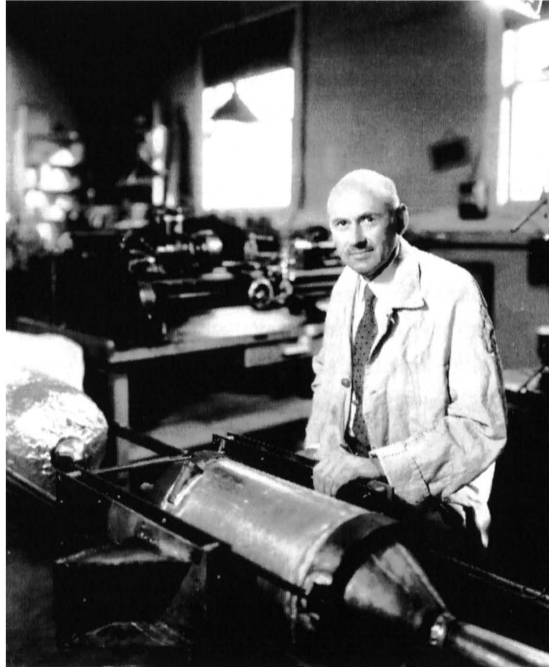


Figure 10–2: Robert Goddard. Credit: Smithsonian National Air and Space Museum (NASM 2003-4818).

Hermann Oberth’s 1923 publication of *Die Rakete zu den Planetenräumen* (*The Rocket into Interplanetary Space*) then helped spark the formation of a short-lived spaceflight society in the USSR in 1924 (and with it, a revival of Tsiolkovskii’s reputation) and somewhat more stable ones in Austria in 1926 and Germany in 1927. Esnault-Pelterie helped create an international astronautical prize in France in 1928, American and British “interplanetary societies” were founded in 1930 and 1933, respectively, a Dutch rocket club arose in 1934 and an astronautical section of the French astronomical society appeared in 1938. At the outset, the spaceflight movement was fundamentally cosmopolitan in character,

as Frank Winter and Alexander Geppert, among others, have noted.⁶ Transnational communication, reflecting the relatively benign international climate and state of intellectual freedom before the mid-1930s, was a prominent ethic in the early movement. Certain key, multilingual individuals, especially Nikolai Rynin in Leningrad and Willy Ley in Berlin, sought to foster an exchange of ideas across borders, but the key actors also exchanged letters among themselves.

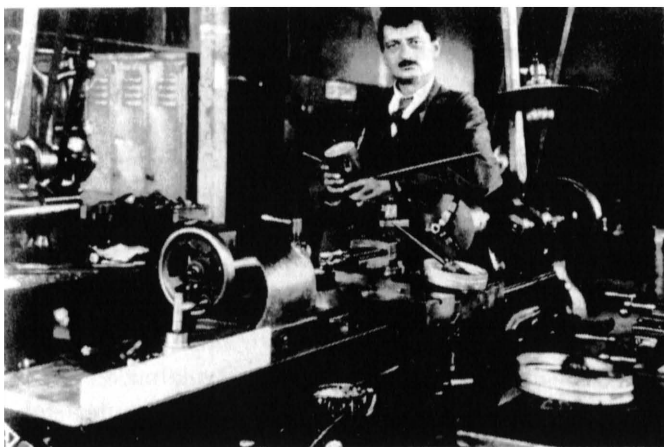


Figure 10-3: Hermann Oberth. Credit: Smithsonian National Air and Space Museum (NASM 87-5770).

When one reads the astronautical literature of the 1920s and 1930s, no clear consensus in the recognition of priorities and founders emerges, although national biases and personal priority claims are apparent. For example, the popular German writer Otto Willi Gail published a survey of the topic in 1928 that rates (in typically nationalist fashion) Ganswindt as a misunderstood genius. He then devotes several pages each to Goddard, Oberth, and the Austrian theoretician Franz Edler von Hoefft (in hindsight a minor figure and even a quasi-fraud), but he never mentions any Russians. Willy Ley's small chronology of the history of the rocket in November 1932 does discuss Tsiolkovskii, but not until 1924, the date of republication in the USSR of the Russian theorist's earlier work, and does not mention Esnault-Pelterie until he reaches 1927. The latter, in his comprehensive work *L'Astronautique* (he coined the term) in 1930, naturally trumpets his priorities in thinking going back to 1908 and in publication going back to 1913, and then gives an extensive laundry list of everyone else who wrote anything else on the topic of spaceflight and rocketry. Alexandr Shershevskii, a Russian then living in Berlin, penned a similar laundry list in 1929 in his survey of the topic in German, but of course gave Tsiolkovskii a somewhat larger role. The American

David Lasser, in the 1931 first popular spaceflight book in English, begins with Esnault-Pelterie, Bing, Goddard, Oberth, and Hohmann, but has no awareness whatsoever of the Russians. Englishman Charles A. Philp, in a popular account published in London in 1935, singles out “Ziolkovsky,” Esnault-Pelterie, Goddard and Oberth, in that order, likely reflecting his correspondence with Willy Ley. Philip E. Cleator, founder of the British Interplanetary Society in 1933, similarly foregrounds those four in his 1936 book.⁷

By far the most comprehensive survey was by Rynin, who issued a pioneering nine-volume encyclopedia, *Mezhplanetnye sooshchenia (Interplanetary Flight and Communications)*, between 1928 and 1932. In his early volumes he comprehensively chronicles every idea and concept for space travel (and also for advanced atmospheric flight and long-range missiles) in nonfiction and fiction—a valuable compendium that includes many long-forgotten and mostly wrong or half-baked ideas. Only in the later volumes does he clearly assign credit. He devotes all of volume 7 to Tsiolkovskii (including the reprint of many of his works), and volume 8 to (in this order): Esnault-Pelterie, Goddard, Oberth, Hohmann, the German spaceflight skeptic Hans Lorenz, and then a dozen others more briefly. Earlier in the series, in volume 4, Rynin makes clear that his fundamental list was five, not three, that is, including Esnault-Pelterie and Hohmann.⁸



Figure 10–4: Nikolai Rynin. Credit: Smithsonian National Air and Space Museum (NASM 76-16742).

Another key Soviet space popularizer was Iakov Perel'man. Asif Siddiqi, in a survey of some of his space works, found that the TGO interpretation can first be seen in Perel'man's 1932 biography of Tsiolkovskii, but a 1935 work adds Tsarist assassin Nikolai Kibal'chich, who drew a vague concept for a rocket airplane shortly before his execution in 1881. In 1937, Perel'man, in another

Tsiolkovskii biography, drops Kibal'chich and foregrounds Esnault-Pelterie instead, but in each case, he emphasized four, not three.⁹

After Stalin's rise to total power in the USSR in the late 1920s and Hitler's seizure of power in Germany in 1933, the intensification or creation of totalitarian police states in those two countries led to an emphasis on secret military rocketry, effectively cutting off Soviet and German rocketeers and space enthusiasts from international communication after about 1935. World War II then interrupted the activities of American, British and French space advocates, who in any case contributed little to theory, so that not much was published about the topic between the mid-1930s and the end of the war.

The first important late-war/postwar work of synthesis in English was Willy Ley's *Rockets* (1944)—Ley had immigrated to the United States in 1935 to escape the Nazis. It was reissued in multiple editions with expanded titles and content until the late 1960s. I had earlier assumed that this book was the origin of the TGO interpretation in English, but his chapters on the 1920s and 1930s are dominated by his entertaining and valuable memoir of his activities in Germany. An earlier chapter on the history of the rocket ends by featuring Ganswindt and Tsiolkovskii equally as two forerunners. The next chapter discusses Goddard, Oberth and Hohmann at the outset. Esnault-Pelterie is dismissed as someone who took an interest in the topic in the late 1920s.¹⁰ Another survey by American Interplanetary Society (later Rocket Society) founder G. Edward Pendray in 1945 provides much more detail about Goddard's life and career than had heretofore been available, and goes on to describe Oberth and especially the Berlin rocket experimenters, with whom Pendray had been in close contact. But as in Lasser's 1931 book, the Russians are entirely missing; another American book of this time, by Herbert Zim, is similar.¹¹



Figure 10–5: Willy Ley. Credit: Smithsonian National Air and Space Museum (NASM 2006-26076).

Two Western European works of around 1950 also shortchange or ignore Tsiolkovskii. Hans Kaiser in *Kleine Raketenkunde* (*Little Rocket Primer*) of October 1949 gives Ganswindt a short paragraph and the Russian a bit longer one, but he devotes six pages to Goddard and nine to Oberth, followed by several more on other Austrian and German pioneers. Arthur C. Clarke's *The Exploration of Space* of 1951, a book about technical feasibility, not history, mentions Goddard and Oberth as founders and ignores the Russian. On the other hand, Alexandre Ananoff, who founded the post-war French astronautical society and was influential in the creation of the International Astronautical Federation, dedicates his 1950 book *L'Astronautique* to "mon maître [my master] Konstantin Eduardovitch Ziolkowsky" and gives him priority for his 1903 paper, while also noting Bing's 1911 patent and Esnault-Pelterie's 1912 speech.¹²

Meanwhile, Soviets had begun to put Tsiolkovskii on a pedestal again under the influence of a Stalinist nationalism that attributed all-important inventions to Russians. At the end of his life, between 1932 and 1935, Tsiolkovskii was hailed as a Soviet hero of aeronautics and rocketry—he had spent more time and effort advocating the metal airship during his lifetime than he ever had on rockets. But during World War II, his name sank back into relative obscurity. After 1946–1947, as Asif Siddiqi has recently demonstrated in *The Red Rocket's Glare*, leading rocket engineers around Sergei Korolev strategically revived Tsiolkovskii's reputation primarily as a space pioneer in order to build a foundation for future Soviet spaceflight projects just as their ballistic missile program was accelerating based on captured German technology. This led to an outpouring of Soviet literature on Tsiolkovskii in the 1950s that asserted his priority as the first and most important space theoretician in the world.¹³



Figure 10–6: Konstantin Tsiolkovskii. Credit: Smithsonian National Air and Space Museum (NASM 78-2461).

This hero worship often took on extreme forms under Stalinism: a short biography by Arkadii Kosmodem'ianskii, which the USSR reissued in English translation at late as 1985, claims that Goddard, Oberth and the other pioneers stole all their ideas from the Russian! The spaceflight entry in the 1954 *Large Soviet Encyclopedia* is more reasonable, in that it gives many paragraphs to Tsiolkovskii, several sentences to Kondratiuk and Tsander, and then mentions in a sentence the pioneering "foreign investigations" of Oberth, Hohmann, Esnault-Pelterie and Goddard. The biographical entries in the 1969 *Soviet Encyclopedia of Space Flight* have a similar balance.¹⁴

The postwar Soviet cult of Tsiolkovskii helped to establish his priorities in thought and publication in the West, reinforcing the writings of Ley and other Western popularizers. Beginning in the 1950s, his role is increasingly acknowledged in spaceflight histories and surveys. To take one example, Heinz Gartmann's 1954 *Träumer, Forscher, Konstrukteure (Dreamers, Researchers, Designers*—but translated as *The Men behind the Space Rockets*) gives Tsiolkovskii a full chapter, following the one on Ganswindt and before the ones on Goddard and Oberth.¹⁵

The Soviet space triumphs that began in 1957 further legitimized Tsiolkovskii's priority claim in the West, but they also fostered a Goddard cult in the United States—a transparent reaction to the Soviet one. Goddard had died in 1945, and his reputation was tended thereafter by his widow, Esther Goddard, and by his longtime supporter and funder, the philanthropist Harry Guggenheim. He was certainly not forgotten, but the topic of space travel did not begin to acquire more public respectability until the 1950s, and the rocket engineers working on missile programs in the United States did not know that much about him, in part because his work had virtually no impact on their technology development, thanks to his penchant for secrecy. But immediately in the wake of Sputnik and the first U.S. satellites in 1958, the U.S. government, media, and the public seized on Goddard as *the* American space hero. In 1959 the Smithsonian posthumously awarded him its elite aeronautical honor, the Langley Medal, and acquired many artifacts from Esther Goddard. The just-created National Aeronautics and Space Administration named its new space center outside Washington, D.C., after him that same year, and the U.S. government paid the Guggenheim Foundation \$1 million in 1960 to settle a long-running suit regarding the violation of his patent rights by government-funded projects (Esther Goddard received 40 percent of the money as an annuity). Milton Lehman's authorized biography followed in 1963, but that only capped a wave of profiles by journalists and space popularizers going back to the beginning of the "space age."¹⁶

Hermann Oberth had no national cult behind him by comparison, as now-divided Germany was no longer a player in rocket development, and West Germany's small spaceflight movement was not very influential in the astronautics movement that revived in Europe around 1950. However, Oberth, the only one of the three still alive (he died in 1989), had Willy Ley and Wernher von Braun in his court, and as they rose to prominence in the United States in the 1950s as space popularizers, and in von Braun's case also as a major rocket engineer, they provided many direct testimonials to his importance to theory and to the foundation of the Weimar movement. Simply Oberth's association with von Braun in the origins of the V-2 missile and Peenemünde was validation in itself, and notably after von Braun became a U.S. and West German national hero in the wake of the launch of the first American satellite, Explorer I. Von Braun made many testimonials to Oberth as his boyhood hero and mentor (more hypothetical than real, as the two never spent more than a few weeks together during von Braun's youth). Of course, as Clary has acidly noted, von Braun also began calling Goddard his boyhood hero before American audiences after Sputnik, and jumped on the bandwagon of the Goddard cult. This was not really cynical, as he did honor Goddard's memory, and did remember his name from his youth, but there was more than a little political calculation in his behavior.¹⁷

Von Braun, for one, does seem to have adopted the TGO interpretation as his master narrative of the early years before there was a clear consensus among space advocates. In his failed *Mars Project* novel of 1948–1949, he called his three “landing boats” for Mars the *Oberth*, the *Goddard*, and the *Ziolkowsky* (the German transliteration of the Russian's name). Of course, he had the *Oberth* land first in the original novel, but in the only fictional part of it published in his lifetime, in a popular magazine in 1960, he opportunistically changed it to the *Goddard*!¹⁸

It may well have been von Braun who cemented the TGO interpretation in place in the 1960s. His influential *History of Rocketry and Spaceflight*, published in 1966 with Frederick I. Ordway III (Ordway in fact did the writing, and a very busy von Braun merely reviewed his text) had the interpretation front and center. Chapter 3, “Pioneers of Space Travel,” elevates the three to a plane much above anyone else. But it certainly did not begin with von Braun, as some earlier popular works in English from the late 1950s and early 1960s seem to be heading in that direction. For example, Martin Caidin's *Rockets beyond the Earth* (1952–1954), singled out the “little-known ... Ziolkowsky” in two sentences followed by paragraphs on Goddard and Oberth. *The Rocket Pioneers* by Beryl Williams and Samuel Epstein (1955–1958) gave biographical chapters to William Congreve (British rocket developer during the Napoleonic Wars), Jules Verne, Kon-

stantin “Ziolkovsky,” Robert Goddard and Hermann Oberth, followed by chapters on the German and American rocket societies and on Peenemünde and the V-2. The 1958 edition is introduced by von Braun, who quotes a *New York Times* editorial two days after Sputnik that equated “Newton and Kepler, Galileo and Copernicus, Tsiolkovsky, Goddard and Oberth.” In a 1961 book, British Interplanetary Society founder Philip E. Cleator credited Tsiolkovskii as the “first person to appreciate the potentialities of the rocket” (omitting Kibal’chich and Ganswindt entirely), then described more extensively the careers of Goddard and Oberth. Esnault-Pelterie he treated as an afterthought.¹⁹

The above preliminary survey cannot establish conclusively when the TGO interpretation became standard in Western media and books, but it does indicate that it likely has to be between 1957 and 1967, when the “space race” was in full flower. Why did it emerge as the standard interpretation during that time and whom did it benefit? The answer to that question must remain somewhat speculative, but several reasons can be deduced. Not only did the historical contributions of the three make it a plausible scheme to space historians and journalists, it served a useful purpose for the media and for governments, that is, simplifying a complicated history for popular consumption, and legitimating both sides of the space race, including the ex-Germans now so prominent in the United States. It also proved useful in the disciplinary formation of the international astronautical engineering community by providing a multinational pantheon of founding fathers. Many standard histories of spaceflight published since have used that interpretation, including Walter McDougall’s ...*The Heavens and the Earth*, William Burrows’ *This New Ocean*, and Tom Crouch’s *Aiming for the Stars*.²⁰

Yet the consensus has not been universal. Soviet rocket-engine designer Valentin Glushko’s 1987 reference work in Russian names four founders, adding Esnault-Pelterie, as does a recent American survey of early rocket history. A new French biography of the latter also unsurprisingly proposes that he should be in the pantheon.²¹ Moreover, there has been some disillusionment in the United States and Russia over the space-age cults of Goddard and Tsiolkovskii. At least since the 1990s, American historians of technology have pointed out Goddard’s minimal practical impact on rocketry, despite scoring a lot of firsts like the liquid-fuel rocket. Muscovites that Tsiolkovskii biographer James Andrews encountered more recently have dismissed the visionary as yet another “Soviet myth,” as have some Russian editorialists in the newspapers.²²

The Validity of the Interpretation

All of the above considerations lead me to my second question, is the TGO interpretation still defensible on the basis of the newest scholarship? It seems to me that there are three fundamental criteria for judging the importance of an individual to proving that spaceflight was a scientific and technical possibility and spreading that idea to the world: (1) publication priority, (2) sophistication of the theoretical content and contribution to the fundamental theory and concepts of rocketry and space travel, and (3) effectiveness in altering regional or world perceptions of the feasibility of the seemingly absurd idea of spaceflight. I do not think that chronological priority in terms of private thinking is meaningful, because in the absence of dated notes, it amounts to nothing but an unsupported claim, and even if there is documentary proof, the effect of such notes and thinking on the world is nil until they are transformed into some public form. Of course, such material is inherently interesting to historians and biographers, but it does not bear on the question of credit for altering the world's perception of spaceflight's feasibility.

In terms of publication priority, Hermann Ganswindt made a speech in 1891 in Berlin regarding his spaceship idea and published it in 1899, but as his understanding of Newtonian physics was faulty and his ideas rather primitive, and his effect on the legitimization of space travel was nil in that time period, there seems to be no reason to change Ganswindt's status as a interesting but minor forerunner.²³ No other credible precursors have appeared either, notably not Nikolai Kibal'chich, who sketched out a rocket airplane, not a space vehicle, before his 1881 hanging (the Soviets later made propaganda out of his story too). Tsiolkovskii, as is well-known, published a pioneering if very obscure paper in 1903, and a more extensive development of rocket theory in 1911–1913, and had previewed many of his ideas for space travel in “stilted” science fiction novels he put out in 1893 and 1895.²⁴ Bing's Belgian patent of 1911 has some sophisticated ideas, including staging and liquid propellants, but it is only a few pages long and has no mathematical apparatus at all. The patent languished in obscurity until the 1920s.²⁵ Esnault-Pelterie's 1912 talk and resulting 1913 paper, “*Considérations sur les resultants d'un allégement indéfini des moteurs*” (“*Considerations on the Results of the Indefinite Weight Reduction of Engines*”), is certainly a pioneering contribution, as it outlines the concept of rocket propulsion propelling a space vehicle to the enormous velocities required for spaceflight. He inspired the Italians Giulio Constanzi, who published a summary in 1914, and Luigi Gussalli, who did not publish until the 1920s, but Esnault-Pelterie's paper seems to have been little noticed elsewhere. Victor Coissac's 1916 book *La conquête de*

l'espace (*The Conquest of Space*) was not only non-mathematical and scientifically flawed; it also was apparently unread.²⁶ At the beginning of 1920 came Goddard's work and in mid-1923, Oberth's, with the effects already described. Walter Hohmann's *Die Erreichbarkeit der Himmelskörper* (*The Attainability of the Heavenly Bodies*) appeared in 1925, followed by a long list of theorists emboldened primarily by Oberth and Tsiolkovskii, notably the Austrians Guido von Pirquet and Hermann Noordung (pseudonym for Potočnik), and the Soviets Fridrikh Tsander and Yurii Kondratiuk, all of whom published in the late 1920s and early 1930s.



Figure 10–7: Hermann Ganswindt. Credit: Smithsonian National Air and Space Museum (NASM 83-2819).

When it comes to theoretical sophistication of their contributions, the list narrows quickly to the well-known names. Tsiolkovskii worked out most of the fundamental discoveries early on: the mathematical theory of rocket flight (requiring an extension of Newtonian dynamics to account for variable mass as propellants are expended), high-energy liquid-propellants (notably liquid hydrogen and oxygen), rocket motor and spacecraft design, and fundamental concepts for survival in space and return to Earth. He did not develop the theory of staging until quite late, the mid-1920s. Following his rediscovery in the USSR in 1924, he published several more books.

Esnault-Pelterie's short 1913 paper was much more limited. He did work out the basic rocket equations and velocities needed for escape and a Moon mission, but missed staging and underestimated the usable energy of high specific-impulse liquid-hydrogen/oxygen propellants. He thus speculated that only atomic processes such as the radioactive decay of radium would provide the energy needed for spaceflight. When news of the Goddard Moon flap reached him in

spring 1920, he thought it a hoax, and it took the exchange of letters between the two of them before Esnault-Pelterie fully understood the implications of Goddard's work, namely that human spaceflight was feasible with staging and chemical propellants. His next work on theory was not until 1927, a long paper in which he developed the mathematical equations much more thoroughly and discussed some of the practical challenges of space travel. It was apparently developed before he became aware of Oberth and the Germans in 1927–1928.²⁷

Goddard's *Method* develops the basic rocket equations, discusses his experiments proving the Newtonian law that rockets would work in a vacuum, and outlines the advantages of staging, but is very restrained on future spaceflight ideas, due to his fear of ridicule and secretiveness about his ideas. The advantages of liquid propellants, notably hydrogen/oxygen, are mentioned only in an endnote and nothing is said about human spaceflight. His most adventurous section is his description of his idea of hitting the night side of the Moon with a multi-stage, solid-propellant rocket loaded with flash powder, the proposal that accidentally set off the press frenzy. In fact his private notes reveal many very advanced concepts, including robotic spacecraft, ion propulsion, solar power, solar sailing, and human space colonization, but none of that was published in his lifetime and little since. He went on to his pioneering rocket experiments, leading to the first liquid-propellant launch until 1926, but did not publish that fact until 1936, when the Smithsonian, his main funder from 1917 to 1929, extracted another report out of him. One can only conclude that he would have contributed even more to spaceflight theory, rocket theory, and the credibility of space travel, if only he had not been so obsessed with keeping the substance of his ideas secret.²⁸

Of all the first space travel works, Oberth's *Die Rakete* is the most comprehensive. It includes a very extensive elaboration of the mathematical theory of rocket flight and propulsion, discusses practical ideas for a sounding rocket and a larger vehicle, elaborates the medical challenges of human spaceflight and discusses advanced concepts. In an appendix, he notes that he only discovered Goddard's *Method* in 1922, during the typesetting of his book. In 1928–1929 he expanded his book into a much longer one, *Wege zur Raumschiffahrt (Ways to Space Travel)*, with much more elaboration of the advanced spaceflight ideas that had been discussed in Central Europe in the intervening years.²⁹

Among the important publications sparked by Oberth's book was Walter Hohmann's *Die Erreichbarkeit* in 1925, yet another independent derivation of rocket theory. Hohmann's work went back to at least 1914, but he hesitated to publish anything until after the appearance of Oberth's book, which influenced him considerably in that he earlier had assumed only traditional solid propellants

were possible. Hohmann's most notable contributions are in celestial mechanics and in studies of reentry into Earth's atmosphere and on landing on other celestial bodies, especially his theory of interplanetary minimum-energy trajectories, sometimes called Hohmann transfer orbits in his honor. The celestial mechanics of travel to the planets was further developed by the Austrian Guido von Pirquet, who published a multipart series in the journal of the German spaceflight society in 1928–1929. One last contributor from Central Europe should be noted, the Slovenian-Austrian Herman Noordung (whose real last name was Potočnik). His *Das Problem der Befahrung des Weltraums* (*The Problem of Space Travel*) is fundamentally a popular work for the public, but is noteworthy for developing the idea of a space station much more than in earlier works, as well as for his choice of geostationary orbit.³⁰



Figure 10–8: Walter Hohmann.
Credit: Smithsonian National
Air and Space Museum
(NASM A-4316-F)



Figure 10–9: Herman Noordung.
Credit: Smithsonian National Air
and Space Museum (NASM A-5145)

Finally, two more Soviet theorists made significant contributions: Fridrikh Tsander and Yurii Kondratiuk, both of whom started long before they had heard of Tsiolkovskii, in 1908 and 1916 respectively. Tsander, a Latvian of Baltic German background, published his first work in 1924 and his book finally, after years of delay due to financial problems and bureaucratic inertia in the state-owned publishing house, in 1932. There is much that is original and interesting in Tsander's work, but he was obsessed with an idea that seems, in hindsight, completely impractical from engineering considerations: a space plane that would ascend to the upper atmosphere with air-breathing propulsion, then melt down large parts of its structure and burn them as propellant, thereby reducing the

problem of mass ratio (the need to have a rocket that is up to 90 percent propellants by weight at liftoff). He wrote a number of other manuscripts on theories of spaceflight, but these were not published in the USSR until after his death in 1933. In the last years of his life Tsander also played a key role in launching liquid-propellant rocketry in his country.³¹



Figure 10–10: Fridrikh Tsander. Credit: Smithsonian National Air and Space Museum (NASM 96-16119).



Figure 10–11: Yurii Kondratyuk. Credit: Smithsonian National Air and Space Museum (NASM 72-7483).

Like Tsander, Yurii Kondratiuk labored for years in isolation and often poverty before publishing his book on space travel, in his case in 1929. Part of the delay in publishing was because he was laying low after the Revolution. His real name was Aleksandr Shargei and he had been politically active as an anti-Bolshevik; to protect himself, he assumed the name of a dead man. In the assessment of Asif Siddiqi, his book was among the most complete and comprehensive examinations of spaceflight, and he notably came up with the idea of having a mother ship and a separate lander, such as was later used in the Apollo program (lunar-orbit rendezvous). However, according to Siddiqi, the book was little noticed in his lifetime, and it was only after World War II that the Soviet Union increasingly picked out Tsander and Kondratyuk as founders not far below Tsiolkovskii in rank.³²

So much for my survey of theoretical contributions. My third criterion for judging the importance of early spaceflight advocates is effectiveness in altering regional or world perceptions of the feasibility of spaceflight. I will not belabor this point as I have discussed several aspects of it already. The impact of Goddard and Oberth's books is clear—the world's perceptions were changed and a significant movement arose in the German-speaking world out of Oberth's publi-

cation. Tsiolkovskii was rediscovered in the USSR as a byproduct, and his work contributed much to the flourishing of the Soviet movement after 1924, which in terms of total productivity of publications, organizational activity and practical rocket experimentation at least equaled the combined efforts of the German-speaking countries. Much of that activity in Europe was sustained by enthusiasts, organizers, and popularizers like Max Valier, Willy Ley, Nikolai Rynin and Iakov Perel'man, who I have not considered in this section, as they essentially built on the work of the theorists. The question thus boils down to who of the other had a major public impact? Certainly Esnault-Pelterie was important to sustaining what activity did exist in France, although it was weak, and in convincing some in France and Italy of the feasibility of spaceflight. Hohmann's work was theoretically important but incomprehensible to the public and he did not much participate in the movement, perhaps because he was fully occupied in his respectable occupation of city architect of Essen. Tsander's contributions in the Soviet Union were especially notable. He was an indefatigable promoter of spaceflight and played a central role in the Moscow GIRD rocket group and the origins of liquid-fuel rocketry in the USSR. Kondratiuk, however, was not very important or visible, probably because he was hiding his true identity.

The net result of the above considerations of all three factors (publication priority, theoretical contributions and social impact) is, as I said at the outset, that the TGO interpretation remains essentially defensible, in my opinion, although certainly not inarguable. The three deserve pride of place due to the combined effects of their early and sophisticated contributions and their impact on the growth of spaceflight societies and public understanding. If there is a contender to be in the same class as the three, it would be Esnault-Pelterie, but as I have argued above, in theoretical contributions and impact, he does not quite measure up to Tsiolkovskii, Goddard and Oberth. Nonetheless, it behooves spaceflight historians, popularizers and museum curators to avoid the simplistic version of the TGO interpretation which has often appeared in print—one in which the three are put on a pedestal far above any of the others.³³ Such a formulation flattens out the contributions of the three, as if they were all the same, obscures the contributions of the other theorists, and diminishes the role of the early popularizers, who often played an essential role in translating the work of the others into an understandable form for the public and technically less adept enthusiasts. The rise of the idea that space travel was scientifically and technically feasible was a complex social process, and much credit does redound to others, whatever their fundamental contributions.

Acknowledgments

I wish to thank Asif Siddiqi, Guillaume de Syon and Frank Winter for their extensive comments and personal research on my behalf, and Alexander Geppert, David DeVorkin and Roger Launius for their comments on various versions of the talk and the paper.

Endnotes

¹ Asif Siddiqi, "Deep Impact: Robert Goddard and the Soviet 'Space Fad' of the 1920s," *History and Technology*, Vol. 20 (June 2004), pp. 97–113, quote on p. 97; David Clary, *Rocket Man: Robert H. Goddard and the Birth of the Space Age* (New York: Hyperion, 2003), p. 255. Tsiolkovskii's name has usually been transliterated as Tsiolkovsky in English. I am using the best current transliteration of Russian Cyrillic as given by Siddiqi and by Andrews (see n. 2).

² Asif A. Siddiqi, *The Red Rocket's Glare: Spaceflight and the Soviet Imagination 1857–1957* (Cambridge and New York: Cambridge University Press, 2010); James T. Andrews, *Red Cosmos: K. E. Tsiolkovskii, Grandfather of Soviet Rocketry* (College Station: Texas A&M University Press, 2009); Clary, see above, n. 1; J. D. Hunley, "The Enigma of Robert H. Goddard," *Technology and Culture*, Vol. 36 (April 1995), pp. 327–350; Frank H. Winter, "The Silent Revolution: How R. H. Goddard Helped Start the Space Age," in *History of Rocketry and Astronautics* (Proceedings of the Thirty-Eighth History Symposium of the International Academy of Astronautics, Vancouver, British Columbia, Canada, 2004), Å. Ingemar Skoog, editor, AAS History Series, Volume 35, IAA History Symposia, Volume 24, (San Diego, California: Published for the American Astronautical Society by Univelt, Inc., 2011), pp. 3–54 (paper IAC-04-IAA.6.15.1.01 presented at the 38th History Symposium of the International Academy of Astronautics as part of the 55th International Astronautical Federation Congress, Vancouver, British Columbia, Canada, 4–8 October 2004), also to appear in another form as "The Impact of Robert H. Goddard" (draft article courtesy of Frank Winter). Oberth has only been reconsidered in passing in the literature regarding the Weimar space movement and his role in the Nazi Germany. See for example my "The Excluded: Hermann Oberth and Rudolf Nebel in the Third Reich," *Quest* 5 (1996), 22–27; also published in *History of Rocketry and Astronautics* (Proceedings of the Twenty-Eighth and Twenty-Ninth History Symposia of the International Academy of Astronautics – Jerusalem, Israel, 1994; Oslo, Norway, 1995), Donald C. Elder and Christophe Rothmund, editors, AAS History Series, Volume 23, IAA History Symposia, Volume 15 (San Diego, California: published for the American Astronautical Society by Univelt, Inc., 2001), pp. 209–222 (paper IAC-95-IAA.2.3.03 presented at the 29th History Symposium of the International Academy of Astronautics as part of the 46th International Astronautical Federation Congress, Oslo, Norway, 2–6 October 1995). Oberth remains a difficult biographical subject because his papers remain in control of the family. As for Tsiolkovskii, the bizarre and repulsive dimensions of his "cosmist" philosophy, which underpinned his interest in space travel, are discussed in Michael Hagemeister, "The Conquest of Space and the Bliss of the Atoms: Konstantin Tsiolkovskii," in *Soviet Space Culture: Cosmic Enthusiasm in Socialist Societies*, edited by Eva Maurer, et al. (London/New York: Palgrave Macmillan, 2011), pp. 27–41.

- ³ A half century ago, the great sociologist of science Robert K. Merton noted the common phenomenon of simultaneous or parallel discoveries: "Priorities in Scientific Discovery: A Chapter in the Sociology of Science," *American Sociological Review*, Vol. 22 (December 1957), pp. 635–659, and "Singletons and Multiples in Scientific Discovery: A Chapter in the Sociology of Science," *Proceedings of the American Philosophical Society*, Vol. 105 (October 1961), pp. 470–486. In the history of technology, the literature is even older. Hermione Giffard, in "The Development and Production of Turbojet Aero-Engines in Britain, Germany and the United States, 1936–1945" (PhD Diss., Imperial College London, 2011), 24, notes a 1922 paper by sociologists William Ogburn and Dorothy Thomas about the frequency of parallel invention.
- ⁴ See above, n. 2. Winter's article has appeared in a popular version: "The Misunderstood Professor," *Air & Space Smithsonian* (April/May 2008), pp. 56–59.
- ⁵ Max Valier, *Raketenfahrt* (Munich: R. Oldenbourg, 1930), p. 186. Willy Ley mentions the Goddard rumors in his October 1926 introduction to his popularization of Oberth, *Die Fahrt ins Weltall* (Leipzig: Hachmeister & Thal, 1926). For Goddard's impact on the early Soviet movement, see Siddiqi, "Deep Impact," cited above, n. 1.
- ⁶ Frank H. Winter, *Prelude to the Space Age: The Rocket Societies, 1924–1940* (Washington, DC: Smithsonian Institution Press, 1983); Alexander Geppert, "Space Personae: Cosmopolitan Networks of Peripheral Knowledge, 1927–1957," *Journal of Modern European History*, Vol. 6 (2008), pp. 262–285.
- ⁷ Otto Willi Gail, *Mit Raketenkraft ins Weltall* (Stuttgart: K. Thienemann, 1928); Willy Ley, *Grundriss einer Geschichte der Rakete* (Leipzig: Hachmeister & Thal, 1932); A. B. Scherschevsky [German transliteration of name], *Die Rakete für Fahrt und Flug* (Berlin: C. E. Volkman, 1929); Robert Esnault-Pelterie, *L'Astronautique* (Paris: A. Lahure, 1930); David Lasser, *The Conquest of Space* (1931; Burlington, Canada: Apogee Books, 2002); Charles A. Philp, *Stratosphere and Rocket Flight (Astronautics)*, 2nd edition (London: Sir Isaac Pitman & Sons, 1935); P. E. Cleator, *Rockets Through Space* (London: George Allen & Unwin, 1936).
- ⁸ Nikolai Rynin, *Interplanetary Flight and Communications*, 9 volumes (Jerusalem: Israel Program for Scientific Translations, 1970–71), notably Vol. 4, p. 160. Another interesting case is the "World's First Exhibition of Models of Interplanetary Apparatus, Mechanisms, Instruments and Historical Materials" in Moscow in 1927. It too devoted special attention to a larger list of theorists, several of them now obscure: Siddiqi, *Red Rocket's Glare*, pp. 93–96, and John Elder, "The 1927 Moscow Exhibition of Interplanetary Machines and Mechanisms," unpublished collection of materials provided to me by the author.
- ⁹ Siddiqi e-mail to Neufeld, 14 March 2011. I much appreciate his willingness to survey this work, as I do not read Russian.
- ¹⁰ Willy Ley, *Rockets: The Future of Travel Beyond the Stratosphere*, 1st edition (New York: Viking, 1944), and *Rockets, Missiles and Space Travel* (New York: Viking, 1951), both Chapters 4 and 5. Ley, in a German article in the early 1950s, similarly puts Ganswindt first: "Geschichte des Raumfahrtgedankens," in Heinz Gartmann, editor, *Raumfahrtforschung* (Munich: R. Oldenbourg, 1952), p. 10. Ganswindt gets one paragraph, the same as Tsiolkovskii.
- ¹¹ G. Edward Pendray, *The Coming Age of Rocket Power* (New York and London: Harper and Brothers, 1945); Herbert S. Zim, *Rockets and Jets* (New York: Harcourt, Brace, 1945).
- ¹² Hans K. Kaiser, *Kleine Raketenkunde* (Stuttgart: Mundus, 1949), pp. 33–54; Arthur C. Clarke, *The Exploration of Space* (New York: Harper Brothers, 1951), pp. 17–18, 183; Alexandre Ananoff, *L'Astronautique* (Paris, Arthème Fayard, 1950), translated as *Astronautics*

(Washington, DC: NASA, 1969), NASA-TTF.2,220. I also surveyed two early postwar Ananoff pamphlets: *Navigation Interplanétaire* (Paris: Éditions Elzévir, 1946) and *Des premières fusées au V-2* (Paris: Éditions Elzévir, 1947), but the first does not cover the history of spaceflight ideas, and the second only discusses practical rocket development—Goddard and Oberth come up, but not Tsiolkovskii.

- ¹³ Siddiqi, *The Red Rocket's Glare*, pp. 66–73, 296–301. Andrews also provides much detail on the Tsiolkovskii cult later in his life (he died in 1935) in *Red Cosmos*, but Siddiqi's account in *The Red Rocket's Glare* corrects some of the assertions about T.'s later career that Andrews makes based on earlier Soviet sources. Siddiqi finds, based on extensive primary research, that the hero cult started much later, in 1932, and that post-World War II Soviet claims of support to T. from immediately after the Revolution are not based in fact. Andrews' strength is in the Imperial Russian part of T.'s life (which was most of it) and his relationship to science popularization.
- ¹⁴ A. A. Kosmodemiansky [transliteration as given in the publication—transliteration in text from Siddiqi], *Konstantin Tsiolkovsky: 1857–1935* (n.p.: General Editorial Board for Foreign Publications, Nauka Publishers, 1985), pp. 98–99; "Interplanetary Communications—Large Soviet Encyclopedia" in F. J. Krieger, editor, *Behind the Sputniks: A Survey of Soviet Space Science* (Washington, D.C.: Public Affairs, 1958), pp. 28–34; G. V. Petrovich, editor, *Soviet Encyclopedia of Spaceflight* (Moscow: Mir, 1969). Petrovich gives a small paragraph biographical entry each to Goddard, Oberth and Esnault-Pelterie, a long paragraph to Kondratiuk and three to Tsander, and two pages to Tsiolkovskii. Neither encyclopedia claims intellectual property theft. According to Siddiqi, Soviet histories in the 1970s and 1980s are more even-handed, with a marked tendency towards four founders: "Tsiolkovskii, Esnault-Pelterie, Goddard, and Oberth, with adjunct members Tsander, Kondratiuk, Hohmann, Noordung and others." Siddiqi e-mail to Neufeld, 14 March 2011.
- ¹⁵ Heinz Gartmann, *The Men Behind the Space Rockets* (London: Weidenfeld and Nicolson, 1955). See also Williams and Epstein, *The Rocket Pioneers*, cited below.
- ¹⁶ Clary, *Rocket Man*, Chapter 12; Milton Lehman, *Robert H. Goddard: Pioneer of Space Research* (New York: Da Capo, 1988) (originally published as *This High Man*).
- ¹⁷ Clary, *Rocket Man*, pp. 249, 252.
- ¹⁸ The novel is not to be confused with its mathematical appendix, which was published separately in German and English versions as *The Mars Project* in 1952 and 1953, respectively. Only recently was the novel published as *Project Mars* (Burlington, Canada: Apogee Science Fiction, 2006); von Braun "Contact Mars" manuscript for *This Week*, 1960, in U.S. Space and Rocket Center archives, Wernher von Braun Papers, file 201-18, more correspondence in 218-1. For the saga of the various versions of the *Mars Project* see my *Von Braun: Dreamer of Space, Engineer of War* (New York: Alfred A Knopf, 2007), pp. 240–247, 251–253, 262–263.
- ¹⁹ Wernher von Braun and Frederick I. Ordway III, *History of Rocketry and Space Travel* (New York: Thomas Y. Crowell, 1966), Chapter 3; Martin Caidin, *Rockets Beyond the Earth*, 2nd edition (New York: McBride, 1954), pp. 44–45; Beryl Williams and Samuel Epstein, *The Rocket Pioneers: On the Road to Space* (New York: Julian Messner, 1958); "Stride into Space," *New York Times*, 6 October 1957; P. E. Cleator, *An Introduction to Space Travel* (New York: Putnam, 1961), pp. 102–107. Von Braun published an article in the *New York Times* for Apollo 11 which reaffirms the trinity and then discusses relative lesser lights like Esnault-Pelterie and Hohmann: "Pioneers of a New Age," *New York Times*, 17 July 1969. A British example is Patrick Moore's *Space* (American edition; Garden City, NY: Natural History Press, 1969), which is not as clear as von Braun and Ordway, but devotes disproportionate emphasis to TGO.

- ²⁰ Walter A. McDougall, *...the Heavens and the Earth: A Political History of the Space Age* (New York: Basic, 1985), p. 20; William E. Burrows, *This New Ocean: The Story of the Space Age* (New York: Random House, 1998), Chapter 2; Tom D. Crouch, *Aiming for the Stars: The Dreamers and Doers of the Space Age* (Washington, DC: Smithsonian Institution Press, 1999). Another recent example is Chris Gainor, *To A Distant Day: The Rocket Pioneers* (Lincoln and London: University of Nebraska Press, 2008). Andrews, *Red Cosmos*, pp. 98–99, notes the interpretation's ubiquity in U.S. popular media such as *Life* magazine.
- ²¹ Siddiqi e-mail to Neufeld, 14 March 2011; Mike Gruntman, *Blazing the Trail: The Early History of Spacecraft and Rocketry* (Reston, VA: American Institute of Aeronautics and Astronautics, 2004); Félix Torres and Jacques Villain, *Robert Esnault-Pelterie; du Ciel aux étoiles, le génie solitaire* (n.p.: éditions confluences, 2007).
- ²² Andrews, *Red Cosmos*, pp. xii, 10. The skepticism about Goddard is best captured in Hunley's "The Enigma of Robert H. Goddard," cited above, n. 2. Despite the space-age cult, the idea was not new. The famous aerodynamicist Theodore von Kármán asserted Goddard's minimal impact on rocketry in his autobiography, *The Wind and Beyond*, quoted in Hunley, pp. 340–341.
- ²³ For the most recent, detailed examination of Ganswindt, see Daniel Brandau, "German Rocket and Space Travel Enthusiasm, 1890s to 1930s," M.Phil. dissertation, Cambridge University, 2009, Chapter 2 (copy courtesy of Daniel Brandau). See also Friedwart Winterberg, "Hermann Ganswindt und seine Gedanken zur Weltraumfahrt im Jahre 1891," *Astronautik*, Vol. 10 (1973), pp. 127–140.
- ²⁴ On the novels, see Siddiqi, *Red Rocket's Glare*, pp. 22–23. For Tsiolkovskii generally see this book and Andrews, *Red Cosmos*, and for Kibalchich, see the latter, pp. 5–6.
- ²⁵ A copy of the Bing patent can be found in the André Bing biographical file, National Air and Space Museum Archives, Washington, D.C., thanks to the work of Frank Winter. Excerpts were published in "Document pour servir à l'histoire de l'astronautique," *L'Astronef*, No. 1 (September 1950), copy in same file.
- ²⁶ Translations of Esnault-Pelterie's 1913 and 1927 papers are in Rynin, editor, *Interplanetary Flight and Communications*, Vol. VIII: pp. 6–15, 19–85. The full version of the original paper before the cuts imposed by the journal editor is given as an appendix to Lise Blosset, "Robert Esnault-Pelterie: Space Pioneer," in *First Steps toward Space—Proceedings of the First and Second History Symposia of the International Academy of Astronautics at Belgrade, Yugoslavia, 26 September 1967, and New York, U.S.A., 16 October 1968*, Smithsonian Annals of Flight, Frederick C. Durant III and George S. James, editors, (Washington, D.C.: Smithsonian Institution Press, 1974), p. 5–31 [reprinted in *First Steps Toward Space* (Proceedings of the First and Second History Symposia of the International Academy of Astronautics, Belgrade, Yugoslavia, 26 September 1967 and New York, U.S.A., 16 October 1968), AAS History Series, Volume 6, IAA History Symposia, Volume 1 (San Diego, California: Published for the American Astronautical Society by Univelt, Inc., 1985), pp. 5–31 (paper presented at the 2nd History Symposium of the International Academy of Astronautics as part of the 19th International Astronautical Federation Congress, New York, U.S.A., 13–19 October 1968)]. For Constanzi, see Antonio Eula, "Guilio Constanzi: Italian Space Pioneer," in the same volume, pp. 71–73, but it is apparent that the author does not know that the Constanzi article is just a summary of the REP 1913 paper. On Gussalli, see Giovanni Caprara, Diana Motta Rubagotti and Franco Ragni, *Luigi Gussalli: Pioniere dello spazio/Space Pioneer* (n.p.: Agenzia Spaziale Italiana and Fondazione Civiltà Bresciana, n.d. (2002)), a bilingual Italian/English edition with both biographical pieces and the subject's publications in both languages. It is apparent from these papers that Gussalli largely pursued marginal technical ideas for space

travel that do not have much historical importance. On Coissac, see Jacques Villain, Frank H. Winter and Frederick I. Ordway III, "Victor Coissac: A Forgotten Astronautical Pioneer and Contemporary of Konstantin Tsiolkovsky, Robert H. Goddard and Robert Esnault-Pelterie," in *History of Rocketry and Astronautics* (Proceedings of the Thirty-Fifth History Symposium of the International Academy of Astronautics, Toulouse, France, 2001), Christophe Rothmund, editor, AAS History Series, Volume 32, IAA History Symposia, Volume 21, (San Diego, California: Published for the American Astronautical Society by Univelt, Inc., 2010), pp. 15–35 (paper IAC-01-IAA.2.1.05 presented at the 35th History Symposium of the International Academy of Astronautics as part of the 52nd International Astronautical Federation Congress, Toulouse, France, 1–5 October 2001).

- ²⁷ See previous note for REP's publications. Frank Winter comments on Esnault-Pelterie's 1920 correspondence with Goddard in "The Impact of Robert H. Goddard" (draft article).
- ²⁸ Both the 1919 and 1936 publications are reproduced in Robert H. Goddard, *Rockets* (New York: American Rocket Society, 1946). I owe my comments on Goddard's private notes to Frank Winter, who has been researching Goddard for some time. On the secrecy issue, I agree with the traditional interpretation of his behavior, rather than Clary's. Clary, *Rocket Man*, pp. 107–108, 199–200, 259, notes all the attempts Goddard made in the 1920s to correct the record and explain his ideas, and thus calls him a "publicity hound" (p. 259). Goddard was no recluse, but really was only trying to defend his reputation. He was extraordinarily stingy with giving out any details of his rocket experiments and advanced thinking.
- ²⁹ Hermann Oberth, *Die Rakete zu den Planetenräumen* (1923; Feucht: Uni-Verlag, 1960), and *Wege zur Raumschiffahrt* (Munich: R. Oldenbourg, 1929).
- ³⁰ Hohmann's work is translated into English in Rynin, *Interplanetary Flight and Communications*, Vol. VIII: pp. 183–262; Guido von Pirquet, "Fahrtrouten," *Die Rakete*, Vol. 2 (1928), pp. 67–74, 93–94, 107–109, 117–121, 134–140, 155–159, 169–171, 183–190 and Vol. 3 (1929), pp. 9–13, 40–42, 58–59; Hermann Noordung, *The Problem of Space Travel: The Rocket Motor* (Washington, DC: NASA History Office, 1995).
- ³¹ Tsander's work is gathered in the translated Soviet book, F. A. Tsander, *Problems of Flight by Jet Propulsion: Interplanetary Flights* (Jerusalem: Israel Program for Scientific Translations, 1964); Siddiqi, *Red Rocket's Glare*, pp. 114–121, 136–143; Siddiqi e-mail message to Neufeld, 21 January 2011.
- ³² Siddiqi e-mail message to Neufeld, 21 January 2011. Kondratiuk sent Rynin an autobiographical sketch, printed in *Interplanetary Flight and Communications*, Vol. VIII: pp. 327–331, albeit without revealing his true name.
- ³³ On a personal note, I had to confront this issue directly during the formulation of the *Rocket Pioneers* section of the new *Pioneers of Flight* gallery at the National Air and Space Museum, opened November 2010. Considerations of space forced us (me and my colleague, Cathleen Lewis) to reduce the number of labels, with the result that many biographies of the pioneers had to be sent to a computer interactive, and the main labels focused on TGO, with some briefer discussion of the popularizers. This experience helped to clarify my thinking that the TGO interpretation is still defensible. Nonetheless, we attempted to save at least some of the complexity through the labels and the biographical computer interactive.