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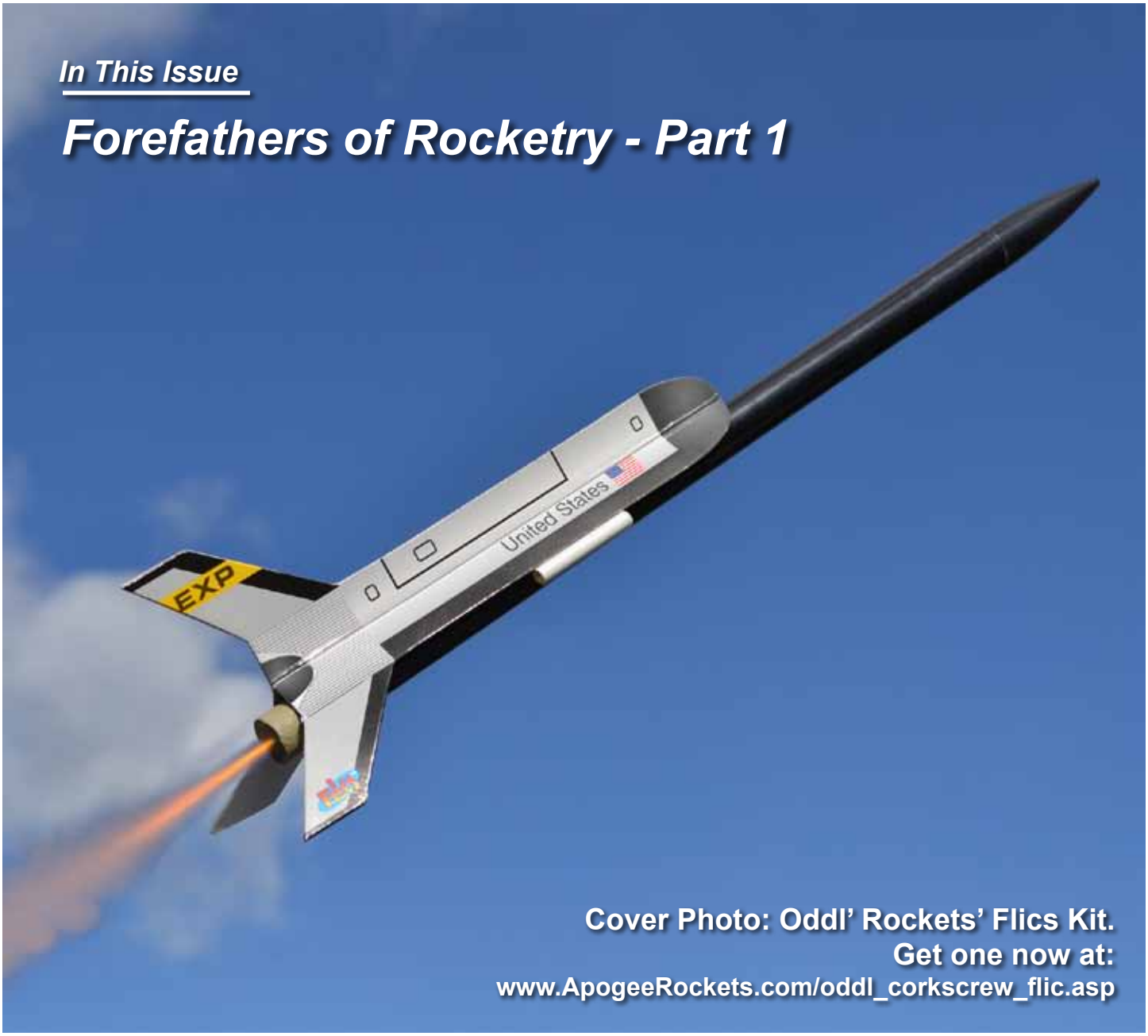

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Forefathers of Modern Rocketry: Part 1

By Bart Hennin

The "Forefathers" of Modern Rocketry were actually "Four Fathers" of Modern Rocketry (plus one Grandfather). In model rocketry, we often take inspiration from REAL rocket scientists. This two-part article examines the fascinating lives, accomplishments, and eccentricities of modern rocketry's early visionaries.

When we think of innovations, we tend to credit a single person with any new invention.

For example, when we think of the telephone it brings a single name to mind - A.G. Bell. Similarly, the invention of the reflecting telescope brings Sir Isaac Newton to mind.

Even the ubiquitous AIRPLANE had no more than TWO inventor's names associated with it, and they were brothers!

On the other hand, when we ask who 'invented' the modern day ROCKET, we must include not just one or two names, but FIVE! Each of these "brilliant five" were obsessive in their own way and each was a "crazy" dreamer who believed mankind could have a brighter future. Each worked independently or mostly so (and often in isolation on different continents).

Though separate, these five had in common a dogged determination to pursue what they believed in rather than what was popular. Their work and adventures left us with inspirational quotes, accomplishments, and a brighter future. Most importantly, each of these five men showed us that when we dare to dream big, we can aspire to accomplish great deeds!

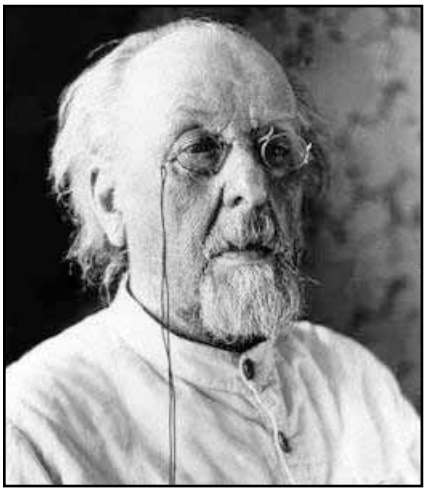
This article is a celebration of the "FOUR Fathers" of modern day rocketry, Robert Goddard, Hermann Julius Oberth, Sergei Korolev and of course Wernher von Braun; It also includes a tribute to the GRANDFATHER of modern day rocketry, Konstantin Tsiolkovsky, who preceded them all.

Each of these men overcame huge personal hardships to make great and historically vital contributions to the field of modern rocketry. Each man courageously brought forth radical ideas that, though they sounded crazy at the time, turned out to be brilliant insights that would ultimately bring space exploration from the realm of fantasy into the realm of feasible reality!

Let's meet these fascinating rocketeers.

Konstantin Tsiolkovsky

We'll start with the one whom I've termed the grandfather of modern day rocketry,



Konstantin Tsiolkovsky. He lived from September 17, 1857 to September 19, 1935.

I refer to Tsiolkovsky as grandfather of modern day rocketry (rather than father) because: 1) He preceded everyone else, 2) He was as much a 'philosopher' as he was 'scientist', 3) Though he submitted a plethora of designs, he never actually built a flying rocket; But he still laid out important theoretical aspects of rocket flight. Tsiolkovsky's revolutionary scientific ideas laid a solid groundwork upon which future rocket building endeavors would rely. Interestingly, he accomplished this with NO formal education!

Konstantin Tsiolkovsky was born to a lower middle-class family in Izhevskoye in what was then in the Russian Empire (now in Spassky District, Ryazan Oblast). He was stricken at age 9 with scarlet fever, which left him severely hearing impaired for the rest of his life. As such he was not allowed to enter school and so he had to teach himself, making use of the only free library near where he lived. Young Tsiolkovsky was determined to prove himself smarter and cleverer than others despite his disability.

His lack of knowledge as to what was current in science at his time led to him independently producing the 'theory of gasses' (even though it had already been known for some time). The KEY idea Konstantin showed was that a rapidly expanding gas (presumably generated from a

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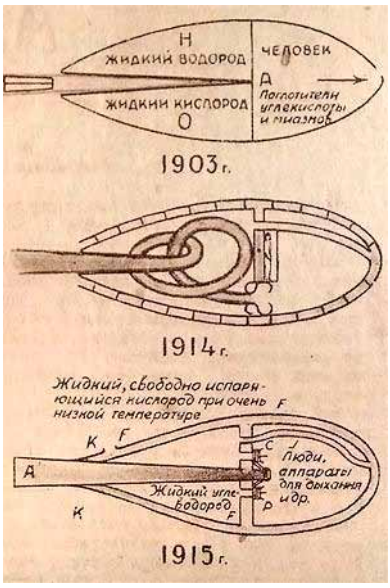
rapid chemical reaction) could produce a directed force. He viewed that such a reactionary force machine could in fact be used to propel a payload, or even a man into space.

For all his interest in science and rockets, Tsiolkovsky saw these works as mere supplements to his philosophical research of which he produced some 400 works (approximately 90 of which were directly related to space travel). His space related designs included rocket steering thrusters, multi-stage boosters, space stations, airlocks, and closed cycle biological systems (to provide food and oxygen for space colonies).



Konstantin's conceptual design of a reaction machine - using rapidly expanding gasses to PROPEL a payload into space.

Tsiolkovsky saw the Earth as finite. He assumed humankind would soon outgrow its living space and resources. *"For me, a rocket is only a means - only a method of reaching the depths of space - and not an end in itself... There's no doubt that it's very important to have rocket ships since they will help mankind to settle elsewhere in the universe. But what I'm working for is this resettling... The whole idea is to move away from the Earth to settlements in space."*

He also said: *"We are further compelled to take up the struggle against gravity, and for the utilization of celestial space and all its wealth because of the overpopulation of our planet."*

He also saw our home planet as fragile and vulnerable in a time when such ideas were normally not thought of nor given serious consideration.

In his own words...

"Man must at all costs overcome the Earth's gravity and have, in reserve, the space at least of the Solar System. All kinds of danger wait for him on the Earth... For instance, a cloud of bolides [meteors] or a small planet a few dozen kilometers in diameter could fall on the Earth, with such an impact that the solid, liquid or gaseous blast produced by it could wipe off the face of the Earth all traces of man and his buildings."

These words are amazing when we realize that they came in a time of scientific naivety where scientists remained unaware of the many violent collisions that historically occurred (and are occurring) in our solar system. Theories such as dinosaur extinction being due to a

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massive asteroid impact (in the Yucatan Peninsula) were still many decades away from discovery! It has only been in recent years that NASA and other private and public agencies have begun to recognize the Earth-wide hazard of killer space collisions that could wipe human life off the planet. Konstantin correctly pondered these dangers in the late 1800's!

Though self taught, Tsiolkovsky was able to pass the required exams to become a teacher, and from 1880-1892 he taught mathematics. During this same period, he also began his scientific research in air balloon building (he wanted to build an all metal dirigible that could change volume and thus run on hot air rather than helium), life in free space, aerodynamics and philosophy.

In 1897, Tsiolkovsky derived and published the fundamental rocket equation that relates a rocket's maximum delta-V (maximum change in speed possible) as a function of its effective exhaust velocity, its initial mass, and its final mass. In this same year he developed the first aerodynamic laboratory (wind tunnel) in Russia in his apartment!

In 1903 came his most important work, *"The Exploration of Cosmic Space by Means of Reaction Devices".* In this work, Tsiolkovsky showed that the horizontal speed required for a minimal orbit around the Earth is 8,000 m/s (5 miles per second) and that this could be achieved by means of a multi-staged rocket fueled by liquid oxygen and liquid hydrogen.

From 1926-1929 Tsiolkovsky solved the practical problem of how much fuel a rocket required to leave the Earth. It turned out that the final speed of the rocket (at burnout) depended on the rate of gas flowing from its nozzle, and also on the ratio of full fuel weight to empty fuel weight of the rocket.

Tsiolkovsky conceived of a large number of ideas that have been used in rockets. This included using graphite gas rudders for rocket flight control, and circulating cold fuel around vital components of the rocket engine (such as the outer the walls of the combustion chamber, the nozzle, and fuel pumps) to keep them from melting. (He also suggested using cold fuel to cool the shell of the spacecraft during re-entry to Earth!).

He calculated the optimal descent trajectory of a spacecraft returning to Earth from space.

In the field of rocket propellants Tsiolkovsky studied a large number of different fuel / oxidizer pairings and made recommendations. He also did pioneering work on the theory of jets, and even published a design of a train riding on an air cushion!

In short, Tsiolkovsky was a visionary beyond his time.

Robert H. Goddard

Dr Robert Hutchings Goddard: October 5, 1882-1945

Imagine this scene: sirens wailing as a police car plus TWO ambulances race along the Massachusetts rural highway leading to Effie Ward's farm. They were followed by a long line of cars. Dr Robert Hutchings Goddard, to his chagrin, was at times a huge attention getter!

Neighbors had reported what looked like a plane crash. Goddard, oblivious to the impending arrival of emergency services, was stooped with his four assistants examining the twisted metal pieces strewn across his rela-

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tive's farm field. Moments earlier this scrap heap had been a functioning liquid fueled rocket!

With a loud roar and atop a bright white flame, the 35 pound, 11.5 foot rocket had climbed some 80 feet straight up, arced to an angle, climbed another 10 feet, and then plummeted to the ground with its parachute failing to deploy. Upon impact the rocket's fuel tank exploded.

This wasn't Goddard's first liquid-fueled rocket launch... that 1st historical launch had been accomplished (with complete success) a little more than 3 years earlier on March 16, 1926, and marked the world's first successful launch of a liquid fueled rocket!

This particular launch and crash, was a *first* in a different way. It was the first time a liquid fueled rocket had carried scientific instruments aloft. The rocket pieces that presently lay strewn about in the farm field included the scientific payload (consisting of one thermometer, one barometer, and one camera. The camera wasn't used to photograph the countryside as one might think. It had a more practical purpose; It was needed to photograph the readings on the instruments during the flight). Luckily most of the rocket pieces and scientific payload were undamaged.

As the emergency vehicles swept in and police rushed towards Goddard, he greeted them with a courteous smile. "Just a little rocket experiment", Goddard said cordially. And then added that he'd be grateful if they kept this thing quiet...

In 1912, the press had laughed and openly mocked Goddard's scientific discussions where he suggested that rocket power could get us to the Moon. Ever since this ridicule, Goddard retreated into a distrustful, obsessive secrecy about his work. So secretive and private had his research now become, that other renowned scientists and rocket inventors around the world remained largely ignorant of Goddard's important work and ground-breaking achievements. In fact, Goddard's counterpart in Germany, Hermann Oberth, remained largely unaware of Goddard's work through much of his life!

As it turned out, it was too late to keep the press at bay this day. Reporters were already arriving in droves. Some were already examining the blackened rocks at the launch site, which were charred and still warm from the rocket's powerful exhaust. The next day the headline read, *"Terrific Explosion As Dr Goddard of Clark Shoots His Moon Rocket!"* To Goddard's frustration, he was in the news again....

Born in Worcester, Massachussetts, young Robert was a curious child and quite fascinated with inventions. Through childhood, Robert was frequently bedridden with illness. As such, he took to reading. With respect to being confined to bed, Goddard said, *"But perhaps revelation often comes when you're not looking for it, resolution when you don't realize you need it."* In fact, young Goddard became obsessively inspired by H.G.

Dr Goddard's 1st successful liquid propelled rocket just before launch.

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Wells', War Of The Worlds. Upon reading it, he immediately started filling many notebooks with outlandish ideas on how to get off of the Earth!

Goddard began working on the development of rockets in 1907 at the Worcester Polytechnic Institute. To the initial consternation of the school administrators, Goddard started firing off powder rockets in the basement of the school's physics lab. Fortunately, school administrators came to accept and even approve of Goddard's noisy research.

Dr Robert Goddard is most famous for building and successfully launching the world's first liquid fueled rocket. However, he contributed much more to rocketry than this single event implies. Goddard and his team launched over 30 more rockets between 1926 and 1941, and they achieved altitudes as high as 2.6 km (1.6 mi) with speeds as high as 885 km/h (550 mph).

As mentioned, 1912 was when Goddard started to discuss publicly (from a scientific point of view) the possibility of using rocket power to get to the Moon, which attracted ridicule from the press and caused Goddard to become highly distrustful and retreat into an obsessive (and at times paranoid) secrecy.

Also during this time, Goddard's health was failing. He was experiencing repeated and severe 'attacks' from tuberculosis. In 1914 he was even told by doctors he had only weeks left to live! Yet with minimal medical care, he recovered and that same year received a patent for a liquid rocket fuel that he developed.

In 1915 he proved rockets would indeed provide propulsion in a complete vacuum. Although most physicists at the time conceded that Newton's third law of motion made this true, a significant and sometimes vocal minority argued that a rocket would not work in the vacuum of space because Newton's reactionary force required something (such as the atmosphere), to push against. In fact the opposite was true...with no 'back pressure' to hold the rocket exhaust back the rocket actually produced MORE thrust in a vacuum!

In 1918 Goddard conducted the first experiments that led to development of the bazooka. Essentially a portable rocket launcher, this weapon was compact enough to be carried by a soldier on the battlefield, yet powerful enough to take out heavily armored enemy tanks.

Goddard published a landmark paper in 1920 called *"A Method of Reaching Extreme Altitudes".* In it, he described in detail the mathematics of rocket propulsion and proposed using rockets to collect meteorological data at high altitudes (higher than balloons could reach).

In 1936 the Smithsonian published Goddard's paper *"Liquid Propellant Rocket Development".* Goddard also conducted research into film cooling and gyroscopically controlled vanes, and over his career he came to hold over 200 rocket related patents!

In the end, Robert Goddard, in spite of his secrecy, left us with a unique legacy. He was optimistic about mankind's future and was very hard pressed to say that anything was impossible.

In his own words... *"It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow."*

His confidence in mankind was unbounded. For example, as a teenager, he took issue with a then prominent aerodynamics expert who said that manned flight would forever be impossible because we don't have the built-in 'flying' intelligence of birds. As a teenager, Goddard observed birds around his home and noted how they subtly steered their flight with fine coordinated movements of their

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wings and tail feathers. He countered that given a properly designed 'control system' man indeed had the intelligence to fly!

For more on Goddard, you can reference Peak of Flight Newsletter # 44 written by Peter Always: www.ApogeeRockets.com/education/downloads/Newsletter44.pdf.

Hermann Julius Oberth

Next, we go to Germany to meet another fascinating rocketry pioneer Hermann Julius Oberth.

Oberth's dogged determination (along with his courageousness to choose what he believed in rather than what was popular) cracked open the door that would lead to an era of big rockets, which would ultimately bring about the exploration of outer-space!

Hermann Julius Oberth (June 25, 1894 to December 28, 1989)

Born in what was then Austria-Hungary, Hermann Oberth was the first person to go much further than just thinking about the possibility of spaceships. Largely (perhaps completely) unaware of Goddard's work, Oberth pursued rocketry in a practical rather than a theoretical way. Rather than using mathematics to theorize, he dared use a slide-rule to make actual engineering calculations! He used mathematical analyses to propose and evaluate actual rocket designs rather than just theoretical ones, and then he pursued building them.

Granted, he would not beat Goddard at being the first to launch a liquid propelled rocket (one of Oberth's early rocket engine designs melted on its test stand in less than 90 seconds, although it did produce a positive thrust until it self destructed), but he would contribute much to rocketry and come to successfully test his own liquid fuel rocket engine in 1929.

Oberth (independent of Tsiolkovsky) came up with the concept of multi-staging as a means to increase a rocket's performance envelope (at a time when this was still a very revolutionary concept!). He stated, *"If there is a small rocket on top of a big one, and if the big one is jettisoned and the small one is ignited, then their speeds are added."*

As a teen, Hermann was tremendously inspired by Jules Verne's ideas and writings (like Goddard). In fact, Oberth obsessively read and re-read Verne's work to the point of memorization!

In 1912, young Hermann enrolled to study medicine but his education was interrupted by WWI. He found himself suddenly drafted into the German army where he eventually became a medic.

In Oberth's own words, *"One of the most important*

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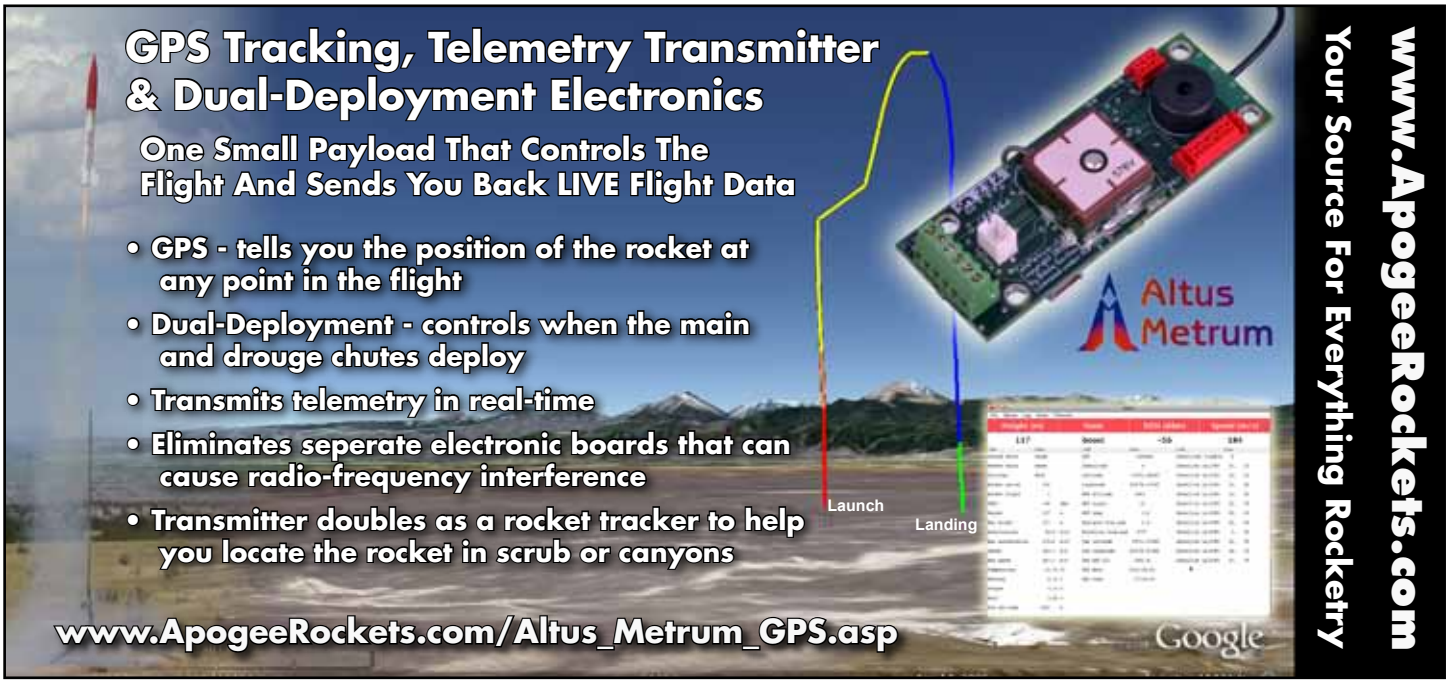

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things I learned in my years as an enlisted medic, was that I DID NOT WANT TO BE a doctor!"

Oberth sustained an injury during the Great War. In spite of the war, his injury, and his duties, Oberth still found time to conduct weightlessness experiments in 1915, and in 1917 he submitted a design to the Prussian Minister of War for a liquid propellant rocket (it was rejected).

In 1922, Oberth submitted his doctoral thesis on rocket science but it was rejected by his science contemporaries as too utopian. Interestingly, Oberth's reaction was NOT to resubmit another doctoral dissertation. Instead he had his existing thesis published (at his own expense) as a book, *By Rocket into Planetary Space* (and by 1929 he had expanded this work to fill a new 429 page book titled, *Ways To Spaceflight*).

In Oberth's own words, *"I refrained from writing another one (doctoral thesis), thinking to myself, never mind, I will prove that I am able to become a greater scientist than some of you, even without the title of Doctor!"*

Conservatively put, Oberth's original book was considered highly controversial. *"The rockets... can be built so powerfully that they could be capable of carrying a man aloft."*

Ridiculous statements like that meant Oberth was not allowed to instruct at the university level and he was consequently forced to support himself and his family by teaching physics and math at a high school.

Ironically, Oberth's second expanded book (based on the first) earned him the coveted *Rep-Hirsch Prize* of the French Astronomical Society for the encouragement of astronautics! Oberth also became a member of the German based "Spaceflight Society" (Verein für Raumschiffahrt or VfR) which was a German amateur rocketry group formed in 1927 (that had taken great inspiration from Oberth's book). Oberth became a mentor to the younger enthusiasts who joined the Society (including an especially bright and hard working teen named Wernher von Braun).

In 1928-29 Oberth accepted a position as scientific consultant on the first film ever made to have scenes in outer space portrayed. This landmark film was called "Woman In The Moon", and its enormous success was responsible in no small way for the popularization of rockets and space exploration. The film was the first to illustrate a pre-launch 'countdown' and also the first to depict 'zero-gravity' (with astronauts floating around the spacecraft cabin).

Unfortunately, plans to actually build and fly a rocket 30 miles up as a publicity stunt never worked. During the making of this movie, Oberth lost his left eye in explosion of one of his rocket engine tests.

The movie's special effects were unsurpassed up to that time and helped popularize space exploration. In 1929, (with the VfR and with assistance from young von Braun) Oberth test fired a newly designed liquid propellant rocket engine. The test was a success!

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Scene from the 1929 movie Woman On The Moon on which Oberth was scientific consultant

Through the 1930's and 1940's and early 1950's, Oberth spent time working or writing in several countries including Hungary, Germany, the USA, and Italy. He worked in 1941 with von Braun at Peenemünde (where research and production of the V-2 rocket was based) and he was awarded the War Merit Cross 1st Class, with Swords for his "outstanding, courageous behavior during an attack on Peenemünde by the allies (during a secret operation named Operation Hydra).

In 1950 Oberth did work for the Italian navy and in 1953 he published yet another book titled, Men in Space, where he described (then) revolutionary ideas such as space-based reflecting telescopes, space stations, and electric-powered spaceships (which have all have become realities today).

Oberth eventually came to work for his former student, Wernher von Braun, who was developing space rockets for NASA in Huntsville, Alabama. Then in 1958, Oberth returned to Germany, where he published his ideas on a lunar exploration vehicle and even a "lunar catapult"!

In 1960, back in the United States again, Oberth went to work for the Convair Corporation as a technical consultant on the Atlas rocket program. He retired in 1962 (at age 68) returning to his homeland Germany.

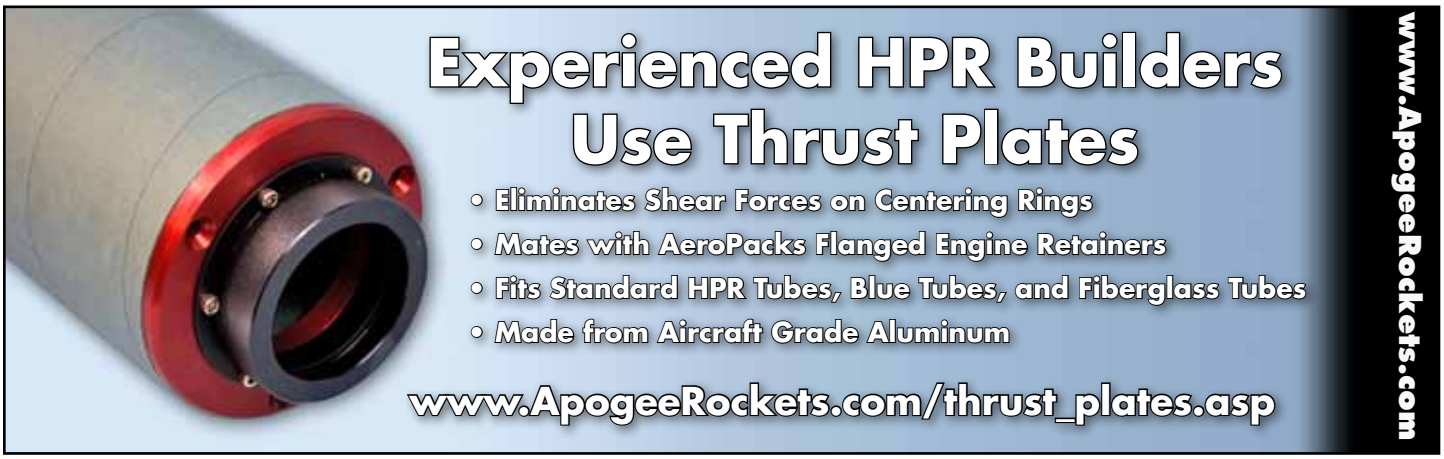
He made trips back to the United States in 1969 and 1985 to witness the launches of Apollo 11 and the Space Shuttle Atlantis respectively.

Interestingly, the 1973 energy crisis inspired Oberth to look into alternative energy sources, including a plan for a wind power station that could utilize the jet stream! If that sounds far fetched, remember that many of Oberth's earlier 'crazy' ideas became realities. Perhaps a future generation will look back and laugh at us for failing to see Oberth's jet stream turbine as an obvious solution to a technological problem!

Coming Next Time:

Sergei Korolev, Wernher von Braun, plus additional reference sources where you can learn even more about these great rocketry pioneers.

About the Author

Bart Hennin graduated in 1984 with a BaSc in Mechanical Engineering from the University of Windsor, Ontario. His senior year thesis was *"Optimization Of A Model Rocket For Highest Altitude"* which earned a top of the class mark of A+. Following graduation, Bart worked for several years in auto manufacturing engineering, then migrated to technical sales, and eventually ended up in general sales and marketing.

Bart is currently married and is living in New York state. Bart says that his family consists of one obnoxious cat named Thor.