A Method of Reaching (more) Extreme Altitudes

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March 16th 2026 will mark the 100-Year Anniversary of the world's first liquid-fueled rocket launch. This rocket, dubbed "Nell", rose to 41 feet during its historic flight, which lasted a hasty 2.5 seconds. Although seemingly trivial in scale, Nell's flight was the first milestone in a long string of innovations that took place in the 20th century. Robert H. Goddard was the man responsible for the design and construction of Nell. He was an influential physicist who helped kickstart a string of Aerospace-related scientific advancement, reaching its apogee in 1969 when Neil Armstrong put human boots on the Moon. In the 21st century, as we look up into the final frontier with renewed vigorosity, Goddard's scientific endeavours can provide a model for the spirit of scientific development, as well as aiding in the design and function of novel propulsion mechanisms.

The legacy of Robert H Goddard is often distilled to the modest height achieved by Nell on its first flight. However, Goddard's true legacy is within physics developments incorporated into Nell. Firstly, the transition from solid fuels such as gunpowder to liquid fuels differentiated Nell from the rockets of the previous 700 years, and addressed the concept of Specific Impulse, a concept quantifying the efficiency of the conversion of rocket fuel into thrust. Nell's novel implementation of the "de Laval" nozzle allowed exhaust propellant to exit the engine at speeds upwards of the speed of sound - suggesting that it could be mathematically possible to generate enough thrust to escape earth's gravity. Despite these improvements in propulsion efficiency, Goddard himself reflected on the limitations of chemical propulsion. In a private diary entry circa 1918, Goddard said that " [if nuclear propulsion] could be used for the propulsion of a rocket, the results would be far beyond anything that could be achieved with the most powerful chemical explosives.". Now, 100 years on from Nell's first flight, we seek another leap in propulsion efficiency, with novel mediums that break the constraints offered by chemical fuel.

One of the most promising contenders for the thrust mechanism type of the future was actually investigated far closer to Goddard's time than we may expect. This is Nuclear Pulse Propulsion (NPP), and it was a concept popularised by NASA's "Project Orion" in the 1960s. Unlike a traditional engine, which involves a constant stream of chemically-ignited fuel out of a nozzle, NPP involves detonating nuclear bombs in the space behind a craft's direction of travel. The released plasma from the explosion slams against a "pusher plate", transferring a large amount of kinetic energy into the craft. Dampeners even out the energy transfer from small bursts to a constant level. While modern rocket engines sit around 450 seconds of Specific Impulse, a nuclear-based system could theoretically achieve levels of upwards of 10,000 seconds. This level of efficiency allows for transfer of city-sized habitats and spacecrafts between planets - unlocking sci-fi potential while still utilising current 21st century technology.

In the future, spacecraft propulsion will likely become multi-modal, utilising different technologies for the different goals of varying spacecraft. Due to the infeasibility of NPP within earth's atmosphere, liquid-fueled rocket engines would likely remain the dominant method of transport for spacecraft taking off from, and landing on earth. Other potentially-disruptive modern propulsion technologies such as Ion Drives and Solar Sails complete the ecosystem. Ionic thrusters, which accelerate charged particles through electromagnetic fields, offer a small yet constant thrust that could be beneficial for small and precise manoeuvring. Solar Sails, which harness the photonic pressure of light or lasers for propulsion, technically have infinite efficiency due to the lack of propellant needing to be stored onboard for a solar sail to function. They could be used for long term interstellar missions, with small crafts involved. The monopoly of chemical propulsion will soon end, and the future will involve much more efficient uses of various different mechanisms of thrust to transport equipment and people in space.

Humanity not only has the will, but also the technical means to develop more effective future means of propulsion. On the forefront of this, Nuclear Pulse Propulsion promises to unlock our capability to move mass in a vacuum, while Ionic thrusters and Solar Sails provide alternatives for different kinds of missions. In this potential future, Goddard's launch of Nell in 1926 symbolises not only the first liquid-fueled rocket launch, but also the first in a long series of innovations, in which humanity figured out the most efficient way to push our spacecraft through the final frontier.

Research:

EMERGING IN-SPACE PROPULSION TECHNOLOGIES

AIAA 2000-3856 - Nuclear Pulse Propulsion - Orion and - Beyond

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