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Cosmic Explorers: Rockets

The Engines That Lift Us to Space

Aira Astralis

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Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

A rocket (from Italian: rocchetto, lit. ''bobbin/spool'', and so named for its shape) is an elongated flying vehicle that uses a rocket engine to accelerate without using any surrounding air. A rocket engine produces thrust by reaction to exhaust expelled at high speed. Unlike jet engines, rockets are fuelled entirely by propellant which they carry, without the need for oxygen from air; consequently a rocket can fly in the vacuum of space, and indeed rocket engines operate more efficiently outside the atmosphere.

Multistage rockets are capable of attaining escape velocity from Earth and therefore can achieve unlimited maximum altitude. Compared with airbreathing engines, rockets are lightweight and powerful and capable of generating large accelerations. To control their flight, rockets may use momentum, airfoils, auxiliary reaction engines, gimballed thrust, momentum wheels, deflection of the exhaust stream, propellant flow, and spin, or may simply fly in a ballistic trajectory under the influence of gravity. Rockets for military and recreational uses date back to at least 13th-century China.

Significant scientific, interplanetary and industrial use did not occur until the 20th century, when rocketry was the enabling technology for the Space Age, including setting foot on the Moon. Rockets are now used for fireworks, missiles and other weaponry, ejection seats, launch vehicles for artificial satellites, human spaceflight, and space exploration. Chemical rockets are the most common type of high-power rocket, typically creating a high-speed exhaust by the combustion of fuel with an oxidizer.

The stored propellant can be a simple pressurized gas or a single liquid fuel that disassociates in the presence of a catalyst (monopropellant), two liquids that spontaneously react on contact (hypergolic propellants), two liquids that must be ignited to react (like kerosene (RP1) and liquid oxygen, used in most liquid-propellant rockets), a solid combination of fuel with oxidizer (solid fuel), or solid fuel with liquid or gaseous oxidizer (hybrid propellant system).

A rocket (from Italian: rocchetto, lit.

Chemical rockets store a large amount of energy in an easily released form, and the consequences of accidents can be severe. The term "rocket" is also used for small fireworks, which are the subject of article rocket (firework). Gunpowder-powered rockets evolved in medieval China under the Song dynasty by the 13th century. They also developed an early form of multiple rocket launcher during this time.

The Mongols adopted Chinese rocket technology and the invention spread via

the Mongol invasions to the Middle East and to Europe in the mid-13th century.

According to Joseph Needham, the Song navy used rockets in a military exercise dated to 1245. Internal-combustion rocket propulsion is mentioned in a reference to 1264, recording that the "ground-rat", a type of firework, had frightened the Empress-Mother Gongsheng at a feast held in her honor by her son the Emperor Lizong.

Subsequently, rockets are included in the military treatise Huolongjing, also known as the Fire Drake Manual, written by the Chinese artillery officer Jiao Yu in the mid-14th century. This text mentions the first known multistage rocket, the 'fire-dragon issuing from the water' (Huo long chu shui), thought to have been used by the Chinese navy. Medieval and early modern rockets were used militarily as incendiary weapons in sieges.

Between 1270 and 1280, Hasan al-Rammah wrote al-furusiyyah wa al-manasib al-harbiyya (The Book of Military Horsemanship and Ingenious War Devices), which included 107 gunpowder recipes, 22 of them for rockets. In Europe, Roger Bacon mentioned firecrackers made in various parts of the world in the Opus Majus of 1267. Between 1280 and 1300, the Liber Ignium (Book of Fire) gave instructions for constructing devices that are similar to firecrackers based on second-hand accounts. Konrad Kyeser described rockets in his military treatise Bellifortis around 1405.

Giovanni Fontana, a Paduan engineer in 1420, created rocket-propelled animal figures. The name "rocket" comes from the Italian rocchetta, meaning "bobbin" or "little spindle", given due to the similarity in shape to the bobbin or spool used to hold the thread from a spinning wheel. Leonhard Fronsperger and Conrad Haas adopted the Italian term into German in the mid-16th century; "rocket" appears in English by the early 17th century.

Artis Magnae Artilleriae pars prima, an important early modern work on rocket artillery, by Casimir Siemienowicz, was first printed in Amsterdam in 1650. The Mysorean rockets were the first successful iron-cased rockets, developed in the late 18th century in the Kingdom of Mysore (part of present-day India) under the rule of Hyder Ali. The Congreve rocket was a British weapon designed and developed by Sir William Congreve in 1804.

Chapter 01: The Discovery of Rockets

This rocket was based directly on the Mysorean rockets, used compressed powder and was fielded in the Napoleonic Wars. It was Congreve rockets to which Francis Scott Key was referring, when he wrote of the "rockets' red glare" while held captive on a British ship that was laying siege to Fort McHenry in 1814. Together, the Mysorean and British innovations increased the effective range of military rockets from 100 to 2,000 yards (91 to 1,829 m).

The first mathematical treatment of the dynamics of rocket propulsion is due to William Moore (1813). In 1814, Congreve published a book in which he discussed the use of multiple rocket launching apparatus. In 1815 Alexander Dmitrievich Zasyadko constructed rocket-launching platforms, which allowed rockets to be fired in salvos (6 rockets at a time), and gun-laying devices. William Hale in 1844 greatly increased the accuracy of rocket artillery. Edward Mounier Boxer further improved the Congreve rocket in 1865.

William Leitch first proposed the concept of using rockets to enable human spaceflight in 1861. Leitch's rocket spaceflight description was first provided in his 1861 essay "A Journey Through Space". The essay was published in a journal in Edinburgh that year before being included in his book God's Glory in the Heavens (1862). Konstantin Tsiolkovsky later (in 1903) also conceived this idea, and extensively developed a body of theory that has provided the foundation for subsequent spaceflight development.

The British Royal Flying Corps designed a guided rocket during World War I. Archibald Low stated "...in 1917 the Experimental Works designed an electrically steered rocket... Rocket experiments were conducted under my own patents with the help of Cdr. Brock." The patent "Improvements in Rockets" was raised in July 1918 but not published until February 1923 for security reasons. Firing and guidance controls could be either wire or wireless. The propulsion and guidance rocket eflux emerged from the deflecting cowl at the nose.

In 1920, Professor Robert Goddard of Clark University published proposed improvements to rocket technology in A Method of Reaching Extreme Altitudes. In 1923, Hermann Oberth (1894-1989) published Die Rakete zu den Planetenraumen (The Rocket into Planetary Space). Modern rockets originated in 1926 when Goddard attached a supersonic (de Laval) nozzle to a high pressure combustion chamber.

These nozzles turn the hot gas from the combustion chamber into a cooler, hypersonic, highly directed jet of gas, more than doubling the thrust and raising the engine efficiency from 2% to 64%. His use of liquid propellants

instead of gunpowder greatly lowered the weight and increased the effectiveness of rockets. In 1921, the Soviet research and development laboratory Gas Dynamics Laboratory began developing solid-propellant rockets, which resulted in the first launch in 1928, which flew for approximately 1,300 metres.

These rockets were used in 1931 for the world's first successful use of rockets for jet-assisted takeoff of aircraft and became the prototypes for the Katyusha rocket launcher, which were used during World War II. In 1929, Fritz Lang's

German science fiction film Woman in the Moon was released.

Push the gas out fast enough and the chamber pushes back: thrust is the equal and opposite answer the engine gives to its own exhaust, the physics a later chapter unpacks in full.

A small solid motor also stands behind every military pilot: when an aircraft is lost, the ejection seat's rocket hauls the crew clear in under a second.

And the sound of a launch is worst at the pad itself, where the roar radiates upward from the nozzle and bounces back off the concrete at the same time.

The word itself has a modest pedigree. Rocket, in its earliest form, came from the Italian rocchetta, a diminutive of the spindle-like distaff used in weaving: the firework tube was named for its shape, a little spindle that flew. The name traveled through French as roquette and into English by the sixteenth century, attached to the same black-powder charges the Italian festivals were already firing at saints' days and city feasts. There is a quiet irony worth savoring in the etymology: the machine that would carry people off the planet took its name from the most domestic tool in the house, the one that held the thread.

The East also fielded the rocket as a rack of tubes. The Korean hwacha, a multiple launcher of the fifteenth century, fired dozens of small fire-arrows from a wheeled cart in a single volley, and it is the clearest ancestor of the modern multiple-launch system: powder-armed, spin-stabilized by the fins already fixed to its arrows, aimed by pointing the whole cart. The machine helped hold a kingdom's border for generations, and its logic, massed cheap rockets against expensive cavalry, is the same logic every artillery officer has relearned since.

The earliest mass-produced rocket was an arrow with a charge. The Chinese fire arrow, a black-powder tube strapped to a bamboo shaft, appears in the military manuals of the eleventh century, volleyed from ranks of tubes and bundles, and its logic survived every dynasty after it: a self-propelled projectile, cheap enough to fire by the hundred, that arrives with fire attached.

The machine's whole career, from the fire arrow to the modern booster, is the career of that one idea given better chemistry.

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ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.