14-03-17 – Funding Ballistic Missile Shields vs. Space Programs

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Concomitant with the miniaturization of nuclear warheads, designers of intercontinental ballistic missiles switched to rocket engines that use solid propellants (fuel/oxidizer) instead of liquid fuel. This made it possible to reduce the nuclear vector and shorten the preparation time for launch. All of the US military forces abandoned liquid fuel rockets in the last twenty years.

In liquid fuel rockets, the liquid fuel and an oxidizer are burned together in a combustion chamber. The fuel flow and the thrust generated can be regulated and the engine can be controlled, making it more fuel-efficient. Solid-fuel rockets are simpler, safer, and cheaper. A fuel and an oxidizer are pre-mixed in a solid form. It is no longer necessary to separate the fuel tanks and cryogenic receptacles, as is required when using liquefied gases (LOX/LH liquid oxygen/liquid hydrogen) and there is no more need for turbopumps to pump the propellant from the tanks into the combustion chamber. However, once combustion begins, the thrust cannot be controlled or turned off, making this a less efficient system.

The evolution of solid fuels.

Dr. Theodore von Karman emigrated from Europe in 1930 to become the first director of the Guggenheim Aeronautical Laboratory at the California Institute of Technology (GALCIT), which later became Aerojet Engineering Corporation. The aim was to study and develop new solid rocket fuels. The first solid fuel, called GALCIT 27, was a black powder made from an organic matrix (the asphalt used in roads) with an inorganic oxidant (potassium nitrate, known as saltpeter). GALCIT 61-C, which was still used after the end of the Second World War, was composed of 76% potassium perchlorate as the oxidizer and 24% fuel (asphalt and motor oil). To get rid of the fumes, the potassium perchlorate was replaced with ammonium perchlorate (NH_4ClO_4). Ammonium perchlorate derivatives are the most widely used fuel rocket today.

It was a big step forward when the asphalt was replaced with an elastomeric polymer. Zinc oxide was added as a hardener or curing agent, creating polysulfides that have a structure and properties similar to rubber. To test the new solid fuel, the Aerojet Engineering company created a small rocket called the "Thunderbird." Weighing 580 kg, the Thunderbird had a thrust of 2,720 kg. The Thunderbird led to the creation of the Sergeant rocket engine and later the XM33 Pollux, which was widely used for the upper stage Vanguard rockets that placed the first US Explorer satellites in space.

From polysulfides they progressed to polyurethane (thermoplastic polymers) by adding aluminum to the fuel composition. Polyurethane can be easily modeled, and was poured directly into the rocket body. ESTANE, the first rocket fuel based on polyurethane, was produced by Goodrich Chemical company, but the most commonly used fuel in this class was PBAA, a copolymer of polybutadiene and acrylic acid, which was first produced in 1967.

Since space rockets are about 80% derived from military ballistic missiles, solid fuel has become the norm in both areas. The most common polyurethane rocket fuel is HTPB (hydroxyl-terminated polybutadiene), produced by ATOChem and was used the Delta II, Delta III, Delta IV, Titan IVB and Ariane rocket boosters. A derivative of the HTPB solid fuel is PBAN, which was used by the two Space Shuttle Solid Rocket Boosters (SRBs) to provide thrust during the first two minutes of flight..

US rocket motors: Recycled from the ICBM and Re-assembled as an Antiballistic Shield

Orbital Sciences Corp (OSC) became famous in April 1990 when the Pegasus, its first ultra-light rocket, was launched from a B-52 bomber (capable of carrying up to 32,000 kg) and managed to place in orbit a 443 kg satellite. The Pegasus ultralight rockets were 17.6 m long and weighed 23,130 kg; they had four stages with solid fuel. The rocket would detach from the airplane at an altitude of 10,000 m and the satellite was placed in a low orbit around the Earth.

This ultra-light rocket was a turning point in the construction of American missiles, showing that it was feasible to build a US anti-ballistic shield. On December 13, 2001, President George W. Bush notified Russia that the US was unilaterally withdrawing from the Anti-Ballistic Missile Treaty. The ABM Treaty limited each signatory to installing Anti-Ballistic systems in just one location. At the same time, the Missile Defense Agency (MDA) was created within the US Defense Department. Technically, this institution was the latest incarnation of President Reagans Strategic Defense Initiative (SDI) program, later restructured and renamed the BDMO (Ballistic Missile Defense Organization) in 1994. The MDA funded OSC (manufacturer of the Pegasus rocket), to assemble ballistic missiles, switching over to the Taurus and Minotaur rockets. The 1,000 three-stage missiles (the LGM-30F Minuteman II, operational from August 1965 until 1997) and the 500 LGM-118 Peacekeepers (the MX, operational until 2005), were decommissioned and subsequently supplied to Pentagon agencies and private companies like OSC, SpaceX (Space Explorations Technologies) and ULA (United Launch Alliance).

The Taurus rocket is assembled by OSC with a launch mass of 73 tons and a payload capacity of 1.3

tonnes for satellites to be placed in low orbit. The first stage of the Taurus rocket is the SR-19. The SR-19 is the second stage of the Minuteman intercontinental ballistic missile and the Peacekeeper MX-II. The SR-19 has a mass of about 7 t, with a thrust of 27,000 kgf. The SR-19 later became the first stage of the GBMD (Ground-Based Midcourse Defense) fixed rocket system for the US Missile Defense Agency. The GBMD shield defends the US Pacific Coast with launch sites in Alaska, California and Hawaii.

The GBMD was developed in parallel with the ABMD (Aegis Ballistic Missile Defense), the naval component of the Ballistic Missile Defense System (BMDS). It uses recycled solid rocket. The US Navy has fifteen Arleigh Burke-class AEGIS destroyers and 22 Ticonderoga-class cruisers. All these vessels are equipped with SPY-1D antiballistic radar and 24 anti-ballistic missiles (the RIM-161/SM-3, launched by the MK-41 Vertical Launch System). AEGIS ballistic systems were installed on six Japanese Kong-AEGIS-class destroyers and three Korean Sejong-class destroyers.

The same AEGIS system has been deployed in Romania, at Deveselu, and it will be deployed in Poland as well. The RIM-161 / SM-3 Block 1b uses the Aerojet MK 72 engine which was the third stage of the American ICBM Minuteman-II rocket, which has been decommissioned.

The US Army has created its own ABM shield called THAAD (Terminal High Altitude Area Defense). A battery consists of 9 launchers x 8 missiles, one radar and two tactical operations centers, all on a M1075 chassis (for 6 x 6 specialty trucks) manufactured by Oshkosh Corporation. The THAAD missiles solid fuel engine is a variant of the Aerojet MK 72.

The Minotaur is the second family of solid fuel rockets from the OSC company. The Minotaur I can launch into orbit an object with a mass of 580 kg. Its first stage engine is a M55A1 (the same as the first stage of the Minuteman II intercontinental ballistic missile) with 80,000 kgF thrust. The second stage (SR-19) is, as mentioned above, the same second stage used in the American Minuteman II and the MX intercontinental ballistic missiles.

The Antares Rocket Disaster

In 20102013, the same Orbital Sciences Corp. bought 40 Russian NK-33 engines and used them in NASA launches, replacing the first two stages of the Minotaur I rocket with two Russian NK-33 liquid fuel engines, each with a thrust of 170,000 kg and functioning for 600 seconds, in order to be able to increase the payload to 2700 kg. The Russians had been using NK-33 engines since 1975 without incident, and the Russian company Energomash delivered them to the Americans. Because of US sanctions on Russia at the beginning of 2014, when the inventory of 40 engines was exhausted, the American side also interrupted the technology transfer with Russia.

For this reason, the White House and the US Senate proposed that the US company Aerojet copy the NK-33 and produce liquid fuel engines, to be designated the AJ26-58/62. Aerojet collaborated on this with the Yuzhnoye design office in Dnipropetrovsk, Ukraine, a design office known in Soviet times as OKB-586, when it designed the Zenith family of light rockets. Two AJ26-58/62 (modified NK-33s) engines constitute the first stage of the new Antares rocket (Taurus II), after the architecture of the first stage of the Soviet Zenith rocket only Aerojet introduced new Ukrainian components into the Russian engines without consulting with the Russian designer, Kuznetsov.

The Ukrainians from Yuzhnoye, although they had owned the engine technology for more than 20 years with liquid fuel, working with liquid oxygen and kerosene, they had never used NK-33 engines from the JSC Kuznetsov (part of the militaryindustrial conglomerate "Rostec") they had been using engines from the Russian company Glushko (the RD-171 and RD-120, designed by OKB-456). These engines use a different type of high pressure turbo pumps.

All these errors came together on October 27, 2014, when the Antares rocket was to carry an American Cygnus cargo ship with supplies to the International Space Station (ISS). Six seconds after take-off, the Antares ran out of fuel and lost thrust, and began to fall. The controllers at the Wallops Island launch center in Virginia were forced to fire the rockets self-destruct mechanism. According to Agence France-Press, the spokesman of Orbital Sciences Corporation acknowledged that "analysis of the available data indicates a fault at one of the two turbopumps in the first stage of the rocket." That ended the cooperation with the Ukrainians. The Russian Soyuz rocket uses the NK-33-1 engine and it works flawlessly.

With the closure of the Space Shuttle Program (2011), ATK (Alliant Techsystems) decommissioned its production line for the most powerful solid fuel boosters in the world. The Pentagon and NASA were left without the most powerful rocket engines that had a thrust of 1.4061 million kg. Lieutenant General Ellen Pawlikowski, commander of the Air and Missile Systems Center (SMC), says that in the next 1015 years the Russian engines will be indispensable, and that only the P238 in the world (which are the first stage of the French Ariane 5 rocket), could help in case of an emergency with the Russian RD-180 engines.

The French Ariane 5 rocket is 50.5 m long, with a mass of 780 t; it can launch 1621 t into orbit. The first stage has two P238 solid rocket motors, each with a thrust of 630,000 kg. The second stage uses the Vulcain 2 engine, using LH2/LOX, with a thrust of 115,000 kg. The third stage uses the Aestus 2/HM-7B engine with a thrust of 6,900 kg, and it can be turned on and off repeatedly.

In December 2014, the White House sent the French President a request to supply P238 engines, but the Ariane 5 ECA only had six launches a year and could not even meet the demand for placing satellites for the European Union. France appealed to Russia for missiles. Russian specialists built the Kourou Space Center (in French Guyana), a new launch pad and rocket assembly hangar, for the Russian Soyuz and Vega; France could not provide the Americans with rocket motors.

Russian and US missile engines from the Apollo missions

Although liquid fuel rockets have a larger capacity, and have far more parts and subassemblies, they remain today the only way to launch objects weighing 2030 tons into space. The White House followed a totally erroneous strategy in directing funding mainly to research and development of solid fuel suborbital rockets, intended for various components of the antiballistic shield, and this prevented NASA and the US Air Force from developing a new generation of space launcher.

On 21 July 2011, upon the completion of the 135th mission, the Space Shuttle Program with manned flights was ended. And with it, NASAs and the US militarys primary launcher disappeared. Even though it invested heavily in creating and maintaining the International Space Station (ISS), the US no longer has the means get astronauts on board and has to appeal to Russia.

Space Dragon

In October 2012, the Space Dragon capsule, built by the American company SpaceX (Space Explorations Technologies), performed its first three-week mission in space without crew. The Dragon capsule carries 400 kg of supplies for the ISS. To launch, it uses a Falcon 9 rocket. SpaceX was founded in 2002 by Elon Musk, the mastermind behind PayPal, as a private company.

Falcon 9

The Falcon 9 is a two-stage rocket, 54 m long, 3.6 m in diameter, with a weight of 333 t ; it can place an object of 6.6 t in a low orbit. The first stage of the Falcon 9 rocket is made up of nine Merlin 1C rocket engines (using liquid fuel, LOX/RP-1), each with a thrust of 56,696 kg. The first stage has a total of 500,000 kg thrust and stage 2 has a single Merlin engine which operates for 345 seconds.

While the Western media talk about the Falcon 9 as something new, it is not nothing but a recycling of old relics from the Cold War. The Merlin 1C engine is a more modest version of the already famous RS-27 engine (93,304 kg thrust), manufactured by Rocketdyne from 1974 to 2000 for the McDonnell Douglas companys Delta rockets. The Delta 2000 can place a satellite of 6 tons in low orbit.

Delta II

More than 70% of the thrust for another rocket used by USAF today, the Delta II rocket family (6000/7000 Series), is provided by the first stage (operating on LOX/RP1). This stage (also equipped with the RS-27 engine) is nothing but an intermediate-range Thor-type ballistic missile (IRBM). The Thor was created in 1959 with a single stage engine (RS-27). SpaceX just copied & pasted the configuration of the Saturn I and Saturn IB rocket for the first stage of the Falcon 9 rocket; they were designed NASAs glory days to serve the Apollo missions. Eight MB-3 (Thor missile, renamed H1) engines were put together to serve as a first stage (S-IB) for the Saturn IB.

Stage 2 (Able) of the Delta II rocket is actually the engine of the Apollo Service Module. It was used to launch the lunar module and the command module into lunar orbit and then to remove them from lunar orbit and propel them back to Earth. Their propulsion was provided by the AJ 10-118 engine (with 4,000 kg of thrust).

For take-off, the Delta II rocket uses small new solid rocket boosters, with a diameter of 1 meter, with a thrust of 6,500 kgF. The rocket boosters use a GEM-40/Castor engine. In 19621977, it was used in the MGM-29 Sergeant short-range, solid-fuel surface-to-surface missile (a range of 135 km) for US land troops.

Delta IV

After NASAs budget was dramatically cut, some of the experts from subsidiaries of Lockheed Martin and Boeing joined forces in 2006 as the ULA (United Launch Alliance). ULAs mission is to put together new rockets from left-over systems and engines at the Pentagon and to provide launch services for American military satellites. Basically the same as for SpaceX, the Delta IV rocket put together by ULA is another example of recycling old rocket stages used in the Cold War. Unlike the series Delta II, Delta IV can place objects weighing 822 tons in orbit.

The Delta IV has two boosters with RS-68 engines using LH2/LOX, each with 337,811 kg thrust. This is actually the main engine of the Space Shuttle, derived in turn from the J-2, the second stage engine of the Saturn IB or the third stage of the Saturn V. The first stage also has an RS-68 motor and the second stage (Centaur) has an RL10 engine, with 11,216 kg of thrust, using LH2/LOX.

Atlas V

ULA also assembles the most powerful American rocket in service (the Atlas V). It is capable of launching into orbit objects weighing 929 tons. At launch, the Atlas V uses two Russian RD-180 booster engines, working with liquid oxygen and kerosene (LOX/RP-1) which each produce a thrust of 423,386 kg. The RD-180 engine is based on the first stage of the Russian Zenith family of rockets produced by NPO Energomash. The first stage of the Atlas V rocket also has the Russian RD-180 engine and the second stage (Centaur) is the same as the Delta IV rocket.

Only the Atlas V rocket can place in orbit the X-37B autonomous (unmanned) spacecraft which are used by the US air forces for their secret missions. Some experts suggest that the X-37B is used for creating, testing and developing new weapons systems that are intended to attack from orbit, anywhere on Earth. The US currently has two X-37B spacecraft built by Boeing that can execute missions lasting 469 days in space. ##

The sanctions levied by the US government against Russia could affect the cooperation between JPL (Jet Propulsion Laboratory), NASA, and the Russian Space Research Institute (Roscosmos). The safest and most often used launchers remain those of the Russians, i.e., the Soyuz and Proton rockets, with a capacity of 12 to 23 t. They carried the crews and cargo to the Salyut and Mir orbital stations and also to the Russian modules assembled at the ISS station (Zarya and Zvezda).

Russia Has Introduced a New Family of Rockets

On December 23, 2014, an Angara-A5 rocket weighing 763,621 kilograms took off from the Plesetsk Cosmodrome. The first stage of the rocket had a thrust of almost 1,000,000 kg and had four boosters with RD-191 engines mounted around a central segment with an RD-191 engine of its own. Aerospace experts were stunned by the RD-191 engine that is capable of reducing the thrust, in flight, from 100% (240,000 kgf) to 30%.

The RD-191 engine can automatically correct the angle and rotation of the rocket to the desired azimuth,, as [t]he combustion chamber of the RD-191 is designed to swing up to eight degrees along two axis (yaw and pitch) in a special gimbal suspension to enable steering of the rocket in flight.[1] This obviates the need for additional correction engines. The hydraulic system is also an innovation in the field. It heats helium to pressurize the fuel tank and to create the hydraulic pressure required for moving the nozzle of the engine.

The first stage of the rocket functioned 211 seconds, achieving a speed of 3 km/s. The first stage was detached at an altitude of 90,435 m; the second stage (which has a 30,000-kg RD-0124 engine) brought the rocket to an altitude of 161,695m, accelerating to a speed of 4.8 km/s. The third stage consists of a 2,000kgF S5.98M engine that can be stopped and restarted repeatedly. The third stage of the rocket accelerated to the first cosmic speed (7.9 km/s) and reached an altitude of 215 km.

Thus some 12 minutes after launch, the payload mass of 25,766 kg made up of several satellites arrived at a stable orbit around the Earth. The propulsion module called Briz-M transferred the satellites from the initial low orbit to a geostationary orbit. The Briz-M rocket engine was switched on and off four times over nine hours. At 5:58 p.m., the Angara-A5 launcher arrived at a fixed geostationary orbit at 35,800 kilometers attitude and an inclination of 0.49 degrees to the equator.

The Angara family of launch vehicles includes the Angara 1.1 light rocket that can put two tons into low orbit (and that can be converted into an InterContinental Ballistic Missile or ICBM). Then there is the two-stage Angara A3 medium rocket that can put objects of 14.6 t to a low Earth orbit, taking the place of the current Zenith rocket that delivers satellites into geostationary and geosynchronous orbit for the Russian military and Russian Space Agency. The Angara rocket family also includes the heavy Angara A5 and the super heavy Angara A7 rocket, in which the RD-191 engines are replaced with more powerful and lighter RD-193, allowing them to put 35 tons into low orbit or 12.5 tons into geostationary orbit. The most powerful rocket in the Angara family is the Angara-100, which can put 100 t into low orbit.

The first Angara to be launched was the Angara 1.2pp rocket, which performed a suborbital flight of 22 minutes on July 9, 2014, with a payload capacity of 1.5 tons onboard. The rocket flew over northern Russia, traveling 57005800 km, and then it fell to the intercontinental ballistic missile impact area in the Kura Test Range (Kamchatka). The Angara 1.2PP did not have the four boosters seen with the Angara-5, the first stage being made up of a single RD-191 engine and the second stage being fed at just a third of capacity. The point was to test the functions of the main components of the rocket Angara-5. The Vostochny Cosmodrome in the Amur region, where construction began in 2011, was specifically designed to launch rockets by 2018, mainly in the Angara family.