ROCKETS, MISSILES, AND MEN IN SPACE. pdf

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*Rockets, missiles, and men in space [Willy Ley] on www.enganchecubano.com *FREE* shipping on qualifying offers.*

In their most basic form, rockets are uncomplicated machines. They comprise a fuel supply, a combustion chamber in which the fuel is burnt, and a nozzle through which the products of combustionâ€"mostly hot gassesâ€"can escape. Early rockets were little more than tubes closed at one end and filled with gunpowder. They were used for fireworks and for maritime rescue as signals and carriers of lifelines , but they lacked the power and accuracy to be useful beyond these highly specialized niches. Military interest in gunpowder rockets was sporadic and limited. Modern rockets emerged between and from the confluence of several technological breakthroughs: Goddard was the spiritual father but not the true founder of American rocketry. Trained as a physicist, Goddard produced rockets notable more for innovative design features than for sound engineering. His genius was prodigious, but his influence was slight. The foundations of American rocketry were laid, in a practical sense, by four small groups of scientists and engineers scattered across the country. The first of these groups, the American Rocket Society, was formed as the American Interplanetary Society in by a group of technically minded New York City science fiction writers they renamed their group in A second important group coalesced in the late s around aerodynamics expert Theodore von Karman at the California Institute of Technology Cal Tech. In time this group gave rise to another early rocket-building firm: Army to apply their expertise to its nascent rocket-building program. All four groups worked closely with the military. Von Karman worked closely with General Henry H. Through their military projects, the rocket designers also made connections with established defense contractors. The foundations of a robust aerospace industry had thus been laid even before the end of World War II. The rockets that emerged from these collaborations in the late s and early s established the basic design elements used by American rockets for the rest of the century. These included multiple stages , lightweight aluminum rocket bodies that doubled as fuel tanks , and swiveling engines for steering High-energy kerosene derivatives replaced gasoline and alcohol in liquid-fuel rockets. Research at Cal Tech produced a viscous solid fuel that produced more power and higher reliability than traditional powders. Thiokol Chemical Corporation improved it and by the s had enabled solid-fuel rockets to match the power of liquid-fuel ones. Combined, these features created a new generation of rockets. The first representativesâ€"such as the Vanguard and Jupiter of the late sâ€"carried the first small American satellites into space. Later examplesâ€"such as Atlas and Titan of the early sâ€"had the power to carry a nuclear warhead halfway around the world or put a manned spacecraft into orbit. Refinements and Applications, â€" President John F. The result was the Saturn V, which made possible nine lunar missions six of them landings between December and December Taller than the Statue of Liberty and heavier than a navy destroyer, the Saturn V generated the equivalent of million horsepower at the moment of liftoff. However, the Saturn series was a technological dead end. No branch of the military had a practical use for so large a rocket, and without the spur of a presidential challenge the civilian space program could not afford to use them for routine exploration. Experiments with nuclear-powered rockets, pursued in the mids, were discontinued for similar reasons. Saturn was, therefore, a typical of American rocket development after Specialization, rather than a continual push for more power and heavier payloads, was the dominant trend. The navy, for example, developed the Polarisâ€"a solid-fuel missile capable of being carried safely aboard submarines and launched underwater. The air force developed the Minuteman as a supplement to the Atlas and Titan. It was smaller, but because it used solid fuel easier to maintain and robust enough to be fired directly from underground "silos. Heat-seeking and radar-guided missiles had, by the Vietnam War â€" , replaced guns as the principal weapon for air-to-air combat. They also emerged, in the course of that war, as the antiaircraft weapons most feared by combat pilots. Warships, after nearly four centuries serving principally as gun platforms, were redesigned as missile platforms in the s and s. Conceived as a vehicle for cheap, reliable access to space, it was powered by three liquid-fuel engines aboard the winged orbiter and two large solid-fuel boosters jettisoned after launch. Both were designed to be reusable. The boosters, parachuted into the Atlantic Ocean after launch, would be cleaned, refurbished, and refilled with solid fuel for later reuse. By the early s the shuttle, since becoming operational in , had achieved neither the high flight rates nor the low costs its designers envisioned. Its reusability was, nonetheless, a significant achievement in a field where, for centuries, all rockets had been designed as disposable, single-use machines. Johns Hopkins University Press, A History of Space Flight. Places rocket development in its social, political, and military context. Rockets, Missiles, and Men into Space. The Heavens and the Earth. Definitive history of the interplay of Cold War politics, military missiles, and the U. Harvard University Press, A compact, nontechnical history of rocket technology.

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SpaceX reusable rockets are better than hypersonic missiles and planes SpaceX reusable rockets are better than hypersonic missiles and planes brian wang October 19, All major militaries and nations are scrambling to develop hypersonic missiles, drones and aircraft. All major countries are working on hypersonic missiles The US, Russia, China are spending billions to develop and deploy hypersonic missiles. Japan, India, Australia and Europe also are working on such systems. Putin has again stated that Russia will have more new hypersonic missiles deployed. Why do hypersonic missiles matter? Hypersonic missiles can fly in different flight profiles. They do not go in a big predictable arcs but can fly low and flat and move around. The world does not have good and proven ICBM defenses. The hypersonic missiles will be tougher to stop. China and Russia are deploying a few hypersonic missiles now. An all-in-one single non-rocket hypersonic system would need three engines. The US Air Force previously had the following timetable for hypersonic weapons. SpaceX and reusable rocket race SpaceX reusable rockets are superior to most of the hypersonic planes that are targeted for SpaceX already has reused first stages. SpaceX rockets go up to mach Reusable rockets are much, much faster. SpaceX hypersonic reusable rocket capabilities will give the US hypersonic plane capabilities 20 years earlier with faster speeds. Faster and longer ranges Blue Origin and China have sub-orbital versions of reusable rockets. Those suborbital systems would repeatedly fly to around mach 10 to Even suborbital systems are faster than most of the hypersonic planes targeted for and are faster than the current missiles deployed from military jets in Russia. The hypersonic missiles that currently exist have ranges of miles or less and even after adding the range of military jet, the range is only miles or less. Reusable rockets can go orbital and go anywhere on Earth. SpaceX is working on a system to recover the faring nose cones and for the current second stage. Controlling flight paths SpaceX has titanium hypersonic grid fins. They alter the flight of the rocket. Other control surfaces are possible for adjusting rocket flight. SpaceX has retrorockets for landing reusable rockets. Again the flight paths can be massively changed. SpaceX has shown that they can relight their rockets for multiple burns that are more dependent upon the amount of fuel. The massive payload capacity means that additional weight could be used to shield a military version of a reusable rocket. SpaceX has talked about flying anywhere on Earth like New York to Singapore for hypersonic passenger flights. They have talked about reflying a Falcon 9 within 48 hours in They have talked about getting this down to 24 hours by just moving and refueling a landed Falcon 9. In theory, a more capable droneship motorized barge could meet up with a tanker drone ship for refueling and a Falcon 9 could relaunch at sea by transferring to and at sea launch platform. There was a Sea Launch company. Hypersonic deployment of many hypersonic missile tips would be like the multiple independently targetable reentry vehicle MIRV used in ballistic missiles since the s. Reusable rockets can do or easily enable everything desired of hypersonic drones and hypersonic planes. Fly at hypersonic speed and return for reuse. By having the drone get to hypersonic speed it would not need turbine or ramjet engines. A simpler hypersonic only engine and a controlled landing and recovery method would be required. Hypersonic planes could be deployed by taking the boost and glide systems under development now where hypersonic wing surfaces enable the flatter flight profile. Reusable rocket engines could be throttled for different speeds. More fuel could be used for suborbital movement and flight changes instead of going to orbit. Not having maximum payload would save fuel for dodging movement or less predictable paths. Reusable rockets would be the flexible deployment platform for simpler hypersonic drones and missiles. The US already has superior space capabilities versus other countries. The developer of the likely second place solution is Blue Origin. By , there could be a fleet of BFR. This would be less than the planned spend for the Space Launch System which would have one or two flights per year. The USA could fly each 50 times and get 10, launches per year. Fully leveraging Spacex BFR fleet would mean the trivial deployment of Project Thor plus the ability to have a space corp of a hundred thousand or more people permanently station in various orbits, the moon, cislunar and other locations. Anti-hypersonic sensors and interceptors Undersecretary Griffin said the only real way to reliably track hypersonic weapons is from space, beyond the horizon limits of terrestrial radars. Hypersonics are about a factor of 10 dimmer than strategic ballistic missiles so they cannot be monitored from a high orbit. There is a policy-decision-making challenge to decide about a LEO space layer sensor layer. The US Missile Defense Agency and Defense Department have started designing space-based missile interceptors and space sensor that will be used for missile defenses and hypersonic defense. Even if an initial system went up for that price or less, they will rapidly increase the scope and scale. DARPA is developing the basic technology for a lot more small space satellites. DARPA plans a 20 satellite demo and then full deployment could start in Many low-earth orbit spy satellites would be tougher for Russia and China to take out. A constellation of low-earth orbit spy satellites could be less expensive and more powerful than a single larger geosynchronous satellite. Beyond missile interceptors to rods from god Kinetic orbital strike rods from god is the hypothetical act of attacking a planetary surface with an inert projectile, where the destructive force comes from the kinetic energy of the projectile impacting at very high velocities. Jerry Pournelle originated the concept while working in operations research at Boeing in the s before becoming a science-fiction writer. The system described in the United States Air Force report was that of foot-long 6. The time between deorbit and impact would only be a few minutes, and depending on the orbits and positions in the orbits, the system would have a worldwide range. There would be no need to deploy missiles, aircraft or other vehicles. Although the SALT II prohibited the deployment of orbital weapons of mass destruction, it did not prohibit the deployment of conventional weapons. The idea is that the weapon would naturally contain a large kinetic energy, because it moves at orbital velocities, at least 8 kilometers per second. As the rod would approach Earth it would necessarily lose most of the velocity, but the remaining energy would cause considerable damage. Some systems are quoted as having the yield of a small tactical nuclear bomb. These designs are envisioned as a bunker buster. With 6â€”8 satellites on a given orbit, a target could be hit within 12â€”15 minutes from any given time, less than half the time taken by an ICBM and without the launch warning. Such a system could also be equipped with sensors to detect incoming anti-ballistic missile-type threats and relatively light protective measures to use against them. In the case of the system mentioned in the Air Force report above, a 6. The US Space fleet could clean up the , pieces of space debris 20, pieces larger than a softball and could hold the space debris in a space station warehouse. The junk would then also be able to formed into junk rods. A thousand smaller rods could be produced without having to fly specifically dedicated tungsten rods. This would be a very credible anti-missile system and a deterrent to any trivial nuclear missile capability from Iran and North Korea. Russia and China would have to depend upon nuclear armed submarines and submarine drones. Plus they would have to develop comparable reusable rocket capability. Russia would still be able to use underwater nuclear weapons to create tsunami attacks. Also, near shore submarine launched attacks would be pretty quick and tough to defend even for Project Thor. The only reasons not to upgrade to this kind of space capability are 1. Corruption where they choose to have a weaker capability so they can continue to pay Lockheed and established contractors 2. Utter incompetence and inability to break out of old thinking 3.

3: Rockets, Missiles & Space Travel by Willy Ley

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Launch of Apollo 15 Saturn V rocket: The main difficulties include cooling the combustion chamber, pumping the fuel in the case of a liquid fuel , and controlling and correcting the direction of motion. They may also have one or more rocket engines , directional stabilization device s such as fins , vernier engines or engine gimbals for thrust vectoring , gyroscopes and a structure typically monocoque to hold these components together. Rockets intended for high speed atmospheric use also have an aerodynamic fairing such as a nose cone , which usually holds the payload. Vehicles frequently possess navigation systems and guidance systems that typically use satellite navigation and inertial navigation systems. Rocket engine Viking 5C rocket engine Rocket engines employ the principle of jet propulsion. Most current rockets are chemically powered rockets usually internal combustion engines , [21] but some employ a decomposing monopropellant that emit a hot exhaust gas. A rocket engine can use gas propellants, solid propellant , liquid propellant , or a hybrid mixture of both solid and liquid. Some rockets use heat or pressure that is supplied from a source other than the chemical reaction of propellant s , such as steam rockets , solar thermal rockets , nuclear thermal rocket engines or simple pressurized rockets such as water rocket or cold gas thrusters. With combustive propellants a chemical reaction is initiated between the fuel and the oxidizer in the combustion chamber, and the resultant hot gases accelerate out of a rocket engine nozzle or nozzles at the rearward-facing end of the rocket. This actually happens because the force pressure times area on the combustion chamber wall is unbalanced by the nozzle opening; this is not the case in any other direction. The shape of the nozzle also generates force by directing the exhaust gas along the axis of the rocket. Rocket propellant Gas Core light bulb Rocket propellant is mass that is stored, usually in some form of propellant tank or casing, prior to being used as the propulsive mass that is ejected from a rocket engine in the form of a fluid jet to produce thrust. The oxidiser is either kept separate and mixed in the combustion chamber, or comes premixed, as with solid rockets. Alternatively, an inert propellant can be used that can be externally heated, such as in steam rocket , solar thermal rocket or nuclear thermal rockets. In these circumstances, it is necessary to carry all the propellant to be used. However, they are also useful in other situations: Military A Trident II missile launched from sea. Some military weapons use rockets to propel warheads to their targets. A rocket and its payload together are generally referred to as a missile when the weapon has a guidance system not all missiles use rocket engines, some use other engines such as jets or as a rocket if it is unguided. Anti-tank and anti-aircraft missiles use rocket engines to engage targets at high speed at a range of several miles, while intercontinental ballistic missiles can be used to deliver multiple nuclear warheads from thousands of miles, and anti-ballistic missiles try to stop them. Rockets have also been tested for reconnaissance , such as the Ping-Pong rocket , which was launched to surveil enemy targets, however, recon rockets have never come into wide use in the military. Science and research See also: The world record for this is Mach 8. Spaceflight Larger rockets are normally launched from a launch pad that provides stable support until a few seconds after ignition. Spacecraft delivered into orbital trajectories become artificial satellites , which are used for many commercial purposes. Indeed, rockets remain the only way to launch spacecraft into orbit and beyond. Also, a rocket may be used to soften a hard parachute landing immediately before touchdown see retrorocket. Rescue Apollo LES pad abort test with boilerplate crew module. Rockets were used to propel a line to a stricken ship so that a Breeches buoy can be used to rescue those on board. Rockets are also used to launch emergency flares. Some crewed rockets, notably the Saturn V [25] and Soyuz [26] have launch escape systems. This is a small, usually solid rocket that is capable of pulling the crewed capsule away from the main vehicle towards safety at a moments notice. These types of systems have been operated several times, both in testing and in flight, and operated correctly each time. This was the case when the Safety Assurance System Soviet nomenclature successfully pulled away the L3 capsule during three of the four failed launches of the Soviet moon rocket, N1 vehicles 3L, 5L and 7L. In all three cases the capsule, albeit unmanned, was saved from destruction. It should be noted that only the three aforementioned N1 rockets had functional Safety Assurance Systems. May Hobbyists build and fly a wide variety of model rockets. Many companies produce model rocket kits and parts but due to their inherent simplicity some hobbyists have been known to make rockets out of almost anything. Rockets are also used in some types of consumer and professional fireworks. A Water Powered Rocket is a type of model rocket using water as its reaction mass. The pressure vessel the engine of the rocket is usually a used plastic soft drink bottle. The water is forced out by a pressurized gas, typically compressed air. Australia, Austria, Canada, Germany, New Zealand, Switzerland, the United Kingdom, and the United States have high power rocket associations which provide certifications to its members to fly different rocket motor sizes. While joining these organizations is not a requirement, they often provide insurance and flight waivers for their members. Hydrogen peroxide rockets are used to power jet packs , [34] and have been used to power cars and a rocket car holds the all time albeit unofficial drag racing record. Rocket exhaust generates a significant amount of acoustic energy. As the supersonic exhaust collides with the ambient air, shock waves are formed. The sound intensity from these shock waves depends on the size of the rocket as well as the exhaust velocity. The sound intensity of large, high performance rockets could potentially kill at close range. These acoustic waves can be so severe that they can destroy the rocket. Noise is generally most intense when a rocket is close to the ground, since the noise from the engines radiates up away from the jet, as well as reflecting off the ground. This noise can be reduced somewhat by flame trenches with roofs, by water injection around the jet and by deflecting the jet at an angle. For the passengers and crew, when a vehicle goes supersonic the sound cuts off as the sound waves are no longer able to keep up with the vehicle. In this case, the nozzle itself does not push the balloon but is pulled by it. Rocket engine The effect of the combustion of propellant in the rocket engine is to increase the velocity of the resulting gases to very high speeds, hence producing a thrust. As the combustion gases approach the exit of the combustion chamber, they increase in speed. The effect of the convergent part of the rocket engine nozzle on the high pressure fluid of combustion gases, is to cause the gases to accelerate to high speed. In a properly designed engine, the flow will reach Mach 1 at the throat of the nozzle. At which point the speed of the flow increases. Beyond the throat of the nozzle, a bell shaped expansion part of the engine allows the gases that are expanding to push against that part of the rocket engine. Thus, the bell part of the nozzle gives additional thrust. If an opening is provided in the bottom of the chamber then the pressure is no longer acting on the missing section. This opening permits the exhaust to escape. The remaining pressures give a resultant thrust on the side opposite the opening, and these pressures are what push the rocket along. The shape of the nozzle is important. Consider a balloon propelled by air coming out of a tapering nozzle. In such a case the combination of air pressure and viscous friction is such that the nozzle does not push the balloon but is pulled by it. If propellant gas is continuously added to the chamber then these pressures can be maintained for as long as propellant remains. Note that in the case of liquid propellant engines, the pumps moving the propellant into the combustion chamber must maintain a pressure larger than the combustion chamber -typically on the order of atmospheres. Therefore, the faster the net speed of the exhaust in one direction, the greater the speed of the rocket can achieve in the opposite direction. Forces on a rocket in flight Forces on a rocket in flight The general study of the forces on a rocket is part of the field of ballistics. Spacecraft are further studied in the subfield of astrodynamics. Flying rockets are primarily affected by the following:

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The missions did not fly with a sustainer engine. Only the two booster engines were included. The first flight, launched on 11 June , was a failure. A total of eight Atlas-A rockets were launched in and Atlas-B missile The Atlas-B missile was the first version to include both the jettison-able booster engines, and the sustainer engine. At launch, all three engines would ignite. Later in the ascent, the two booster engines would shut down and drop away. The sustainer engine would continue firing. Not an operational missile, the Atlas-B was used to further test components of the Atlas missile. Ten Atlas-B missiles were launched during and Three launches were failures. The mission was launched on 18 December Once in orbit, communication experiments were carried out, including the broadcasting of a Christmas message recorded by President Eisenhower. Additional messages were sent to the spacecraft, recorded, and retransmitted to ground stations. Planning for the mission was done in secrete. The first public acknowledgment of the mission occurred only after the spacecraft was in orbit. The Atlas-D was later used to launch Mercury capsules into Earth orbit. All three missions, intended to be Lunar probes, failed. Many space probes were launched on Atlas-Agena rockets. Including all nine Ranger lunar probes , the Mariner 2 and 5 Venus flyby spacecraft, the Mariner 3 and 4 Mars probes, and all five Lunar Orbiter missions. A large number of military spacecraft were launched , including reconnaissance and early warning satellites. During Project Gemini , Agena upper stages were modified to use as docking targets for Gemini spacecraft. The display includes a dummy Agena stage on top. In reality, almost all Atlas-Agena rockets were "Atlas-D" models. Ten Atlas-D rockets flew in support of project Mercury , including two failures and four manned missions. Mercury-Atlas 6, launched on 20 February , placed John Glenn into orbit. Given the call sign "Friendship 7", the successful three-orbit mission was Americas first manned orbital mission. Mercury-Atlas 7, placed Scott Carpenter into orbit on 24 May Mercury-Atlas 9, the final Mercury mission, was piloted by Gordon Cooper and launched on 14 May Atlas-D rocket on display at Kennedy Space Center. A total of five Atlas-H launches took place. Atlas Centaur The Centaur upper stage, powered by two Pratt and Whitney RL rocket engines, was the worlds first hydrogen fueled, high energy upper stage. Hydrogen fuel can offer a significant performance increase over other fuels, especially in upper stages. The first launch attempt, conducted on 8 May , failed. The second test flight, launched on 27 November , succeeded. Atlas Centaur rockets also launched the Mariner 6 and 7 Mars flyby spacecraft, the Mariner 9 Mars orbiter mission, and the Mariner 10 mission. Mariner 10, the first spacecraft to visit two planets, conducted flybys of both Venus and Mercury. A number of Pioneer missions also flew on Atlas-Centaur rockets. Pioneer 10 , the first spacecraft to visit Jupiter, was launched on 2 March Pioneer 11 , launched on 5 April , conducted flybys of both Jupiter and Saturn. Improvements included an enlarged payload fairing. The Russian designed RD engine is fueled with kerosene and liquid oxygen. The new engine represented a significant improvement in both efficiency and reliability over the previous Atlas engines. The switch to the RD engine allowed Atlas to remain viable in the increasingly competitive commercial launch market. The rocket family features a stretched Centaur stage right allowing increased performance over previous versions. The new Centaur second stage can have either one or two RLA rocket engines, allowing performance to better match payload. All previous Centaur versions had two RL engines. Atlas V rockets are given a three-digit model designation. The first digit indicates the payload fairing diameter 4 or 5. The second number indicates the number of solid rocket boosters attached this number can be from 0 to 5. The third number indicates the number of RLA engines on the Centaur stage this will always be either a 1 or 2. The Atlas V , like earlier Atlas variants, features a four meter payload fairing. The fairing is available in a variety of lengths to meet payload requirements. Performance can be increased by adding up to three solid rocket boosters. The booster was a model. Both missions were launched on Atlas V Rockets. An astronaut is included as a scale reference. Atlas V performance can be adjusted by adding up to five solid rocket boosters. The large 5 m payload fairing is available in several lengths. The first Atlas V , a model, launched on 17 July Missions have included several communications satellites and National Reconnaissance Office payloads An Atlas V, model, was used to launch the New Horizons mission to Pluto. The New Horizons launch, on 19 January , imparted a velocity of This is the fastest speed of any space probe so far. New Horizons is on a solar-escape trajectory and will make a close fly-by of Pluto in July of Versions of the LR engine were also used on Thor and Delta rockets. Richard Kruse, Atlas Rockets Illustration.

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Rockets, missiles, and men in space by Willy Ley, , Viking Press edition, in English - [Newly rev. and expanded ed.].

The first stage was powered by two LR rocket engines. The second stage used a single LR rocket. Both stages used kerosene as fuel and liquid oxygen as an oxidizer. The missile entered operational service in Six squadrons, each with nine missiles, were deployed in several western states. The 54 operational missiles were replaced by Titan II missiles in The short-lived Titan I provided greatly needed experience in handling large, multi-stage, ballistic missiles. Experience that would prove useful in later missile programs. The first stage was powered by a pair of improved LR rocket engines. Both stages used hypergolic fuels. Hypergolic fuels are storable at room temperature and ignite when both components come in contact. The use of storable propellants allowed the missile to remain constantly fueled while on alert. The Titan II would be ready to launch in only 60 seconds, much faster then the earlier Titan I version, which needed around 15 minutes to load liquid oxygen immediately before launch. Titan II missiles were on operational alert between and Over the coming decades, the missile evolved into a large number of space launchers. Titan II rockets were also used to launch Gemini missions. The rocket first flew on 8 April A total of 12 missions, all carrying Gemini spacecraft, were successfully launched from launch complex 19 at Cape Canaveral Air Force Station. The first stage was powered by two LRAJ7 rockets. The second stage used a single LRAJ7 rocket. Fourteen of the missiles were refurbished for use as space launchers. Titan 23G was first flown on 5 September Thirteen missions were flown, all from Vandenberg Air Force Base, between and The first stage was powered by two LRAJ5 rockets. The second stage used a single LRAJ5 rocket. A variety of configurations were flown. Some versions used a pair of solid rocket boosters to increase capability. A new upperstage, known as the Transtage, featured a restartable engine, allowing multiple payloads to be placed in different orbits on a singe flight. The first flight, on 2 September , failed. The next three missions succeeded. All missions were launched from launch complex 20 at Cape Canaveral. A pair of large, strap-on, solid rocket boosters were added to the core stage. The payload included a Gemini spacecraft making its second trip into space. The mission included a transtage and several smaller experiments and satellites. A Titan oxidizer tank, mounted between the transtage and the Gemini spacecraft, represented the aerodynamic characteristics of the proposed Manned Orbiting Laboratory MOL. Twenty-two successful missions were flown between and Payloads were KH-9 and KH spy satellites. An astronaut is included as a scale reference. The first launch, on 12 December failed. All additional launches were successful. Payloads included two Helios solar probes, both Viking mars probes , and both Voyager probes. Performance of the TitanD could be matched to payload requirements using a variety of upper stages. Options included the Transtage, the Inertial Upper Stage, or no upper stage. Four missions were launched between and Payloads originally designed for launch on the Space Shuttle could be modified for launch on the Titan IV. The rocket could be configured with a Centaur upper stage, an Inertial Upper Stage, or no upper stage, depending on payload requirements. Military payloads flown included several Milstar communication satellites, signal intelligence satellites, DSP Defense Support Program early warning satellites, and others. A total of 22 Titan IVA rockets were launched, with two failures. At launch, only the solid rockets ignite. When their fuel is exhausted, the SMRUs separate and, with the aid of several small staging rockets, fall away from the core rocket. The core stage, as well as the second stage, are fueled with storable hypergolic propellants. A total of 17 Titan IVB rockets were launched, with two failures.

6: Timeline of rocket and missile technology - Wikipedia

Rockets, Missiles, and Men in Space. Willy www.enganchecubano.com edition. Viking, New York, xvii + pp. illus, $

7: Atlas Missiles and Space Launchers | Historic Spacecraft

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5 At the time, Oberth was a leading figure in the German space movement and author of the highly influential book Die Rakete zu den Planetenraumen (The Rocket into Planetary Space).

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