Office of Nuclear Energy

6 Things You Should Know About Nuclear Thermal Propulsion

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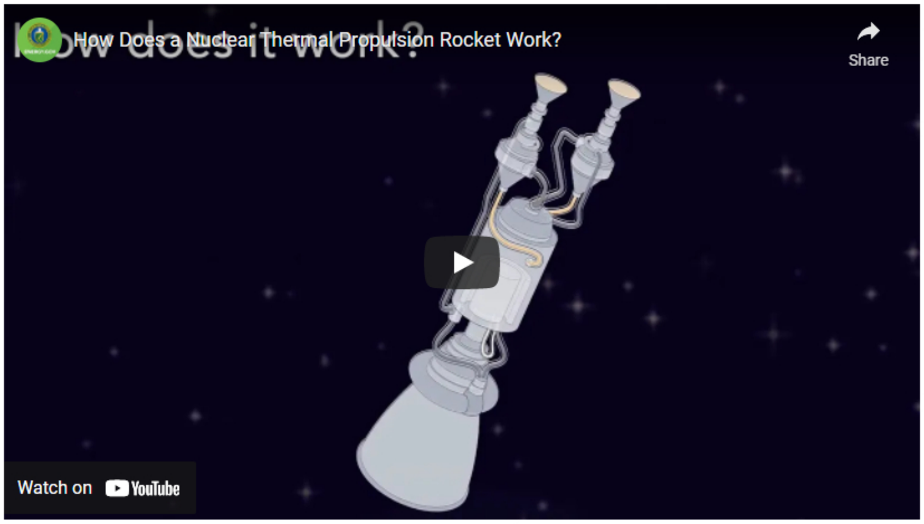
NASA wants to send astronauts to Mars, and they could do it with nuclear-powered rocket engines.

Nuclear thermal propulsion (NTP) systems aren't new, but they could significantly reduce travel times and carry greater payloads than today's top chemical rockets — giving humans a great chance of exploring deep space.

Here are 6 things you should know about nuclear thermal propulsion.



Watch the animation above to learn about the benefits of nuclear thermal propulsion.

Video courtesy of the Department of Energy

1. NTP Systems Are Powered By Fission

NTP systems work by pumping a liquid propellant, most likely hydrogen, through a reactor core. Uranium atoms split apart inside the core and **release heat through fission**. This physical process heats up the propellant and converts it to a gas, which is expanded through a nozzle to produce thrust.

2. NTP Systems Are More Efficient Than Chemical Rockets

NTP rockets are more energy dense than chemical rockets and twice as efficient.

Engineers measure this performance as specific impulse, which is the amount of thrust you can get from a specific amount of propellant. The specific impulse of a chemical rocket that combusts liquid hydrogen and liquid oxygen is 450 seconds, exactly half the propellant efficiency of the initial target for nuclear-powered rockets (900 seconds).

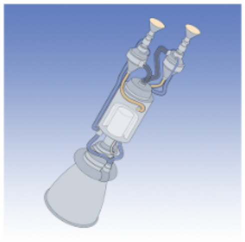
This is because lighter gases are easier to accelerate. When chemical rockets are burned, they produce water vapor, a much heavier byproduct than the hydrogen that is used in a NTP system. This leads to greater efficiency and allows the rocket to travel farther on less fuel.

3. NTP Systems Won't Be Used At Launch

NTP systems won't be used on Earth. Instead, they'll be launched into space by chemical rockets before they are turned on. NTP systems are not designed to produce the amount of thrust needed to leave the Earth's surface.

4. NTP Systems Will Provide Greater Flexibility

NTP systems offer greater flexibility for deep space missions. They can reduce travel times to Mars by up to 25% and, more importantly, limit a flight crew's exposure to cosmic radiation. They can also enable broader launch windows that are not dependent on orbital alignments and allow astronauts to abort missions and return to Earth if necessary.



Download our nuclear thermal propulsion infographic.

5. NTP Systems Were Developed With Support From DOE

NTP is not new. It was studied by NASA and the Atomic Energy Commission (now the U.S. Department of Energy) during the 1960s as part of the Nuclear Engine for Rocket Vehicle Application program. During this time, Los Alamos National Laboratory scientists helped successfully build and test a number of nuclear rockets that current NTP designs are based off of today.

Although the program ended in 1972, research continued to improve the basic design, materials and fuels used for NTP systems.

NASA and DOE are now working with industry to develop updated nuclear thermal propulsion reactor designs. Three industry teams won a design competition in 2021 and are now further developing designs that will be submitted for evaluation for the fall of 2022.

6. NTP Systems Are Focused On Using Low-Enriched Uranium

DOE is working with NASA to help test, develop and assess the feasibility of using new fuels that require less uranium enrichment for NTP systems. This fuel may be made using new advanced manufacturing techniques and can potentially help reduce security-related costs that come with using highly enriched fuel.

Idaho National Laboratory is currently helping NASA develop and test fuel composites at its Transient Reactor Test (TREAT) facility to examine how they perform under the harsh temperatures needed for nuclear thermal propulsion. Initial testing has shown that nuclear fuels under development by NASA and DOE are capable of withstanding ramps up to operational nuclear thermal propulsion temperatures without experiencing significant damage.

Learn more about NASA's nuclear thermal propulsion work and explore DOE's role in space exploration.

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