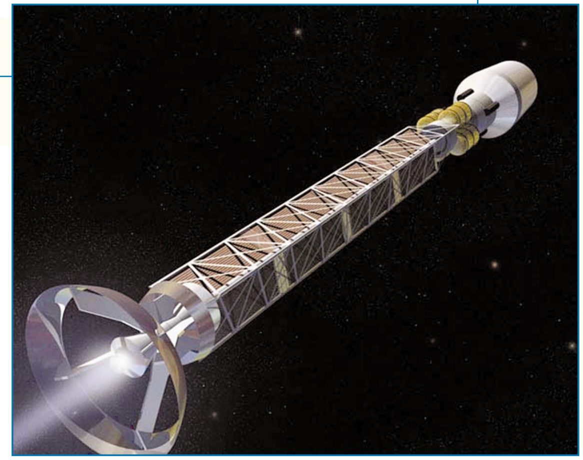
Advanced Space Transportation Technology Summary



Antimatter Propulsion

Traveling to the stars will require ultra high-energy propulsion systems. The mutual annihilation of antimatter and matter packs the highest energy density of any reaction known in physics—perhaps just the energy source needed to trek to the stars.

Antimatter propulsion is a staple of science fiction, and technology development activities now underway in the Advanced Space Transportation Program at NASA's Marshall Space Flight Center in Huntsville, Ala., could loft an antimatter-powered starship into the realm of reality before the close of the 21st century.

Antimatter is the mirror image of normal matter we see all around us. It's composed of subatomic particles that mirror the mass of their ordinary matter counterparts—electrons, protons and neutrons—but with an opposite charge and spin. If the burst of energy produced when particle meets antiparticle could be harnessed, a near-term concept for space propulsion might produce speeds capable of traversing the distance between our planet and the Moon in about 7.5 minutes, or between Earth and Mars in a day. Science missions beyond the outer planets and even the stars could be within reach.

The energy released from proton-antiproton annihilation is 10 billion times greater than oxygen-hydrogen combustion and at least 100 times more energetic than fission or fusion. In other words, one gram of antihydrogen—the mirror image of a hydrogen atom—reacted with an equal amount of normal hydrogen provides the same amount of energy as 23 Space Shuttle External Tanks.

The energy from the matter-antimatter reaction could be used to heat or accelerate a working fluid to propel a spacecraft. Engineers at the Marshall Center are studying the feasibility of hybrid antimatter propulsion concepts that could use antimatter as a "spark igniter" for a fission or fusion reaction. Propulsion concepts that derive all their energy from antimatter annihilation aren't getting much consideration, however, because they require large amounts of antimatter.

Antimatter is very rare in the universe, so it has to be created in a laboratory environment. For almost half a century, antiparticles have been created in laboratories. Only two U.S. labs generate antimatter—Brookhaven National Laboratory in New York and Fermi National Accelerator Laboratory in Illinois. The labs produce antimatter by accelerating particles, such as protons, near the speed of light and ramming them into targets. The current worldwide, annual production of antimatter is only two billionths of a gram.

Dramatic improvements in the production, storage and use of antimatter will be required to make it a viable propulsion alternative. Researchers in the Advanced Space Transportation Program at NASA's Marshall Center, along with their academic partners at Pennsylvania State University of University Park, are focusing efforts on storage of antimatter. Marshall's High-Performance Antiproton Trap, called HiPAT, is the largest trap of its kind in the world, built to hold one trillion antiprotons up to several weeks. The experimental trap consists of an ultra high vacuum electromagnetic container in which protons can be contained so they won't destroy themselves by hitting the container walls or other matter. The trap can be transported by truck to one of the labs that produce antiprotons, filled with the particles, and taken to labs or universities for experiments that could help develop technologies for antimatter propulsion.

As NASA's premier organization for development of space transportation and propulsion systems, the Marshall Center is developing revolutionary technologies that promise a new age of space exploration. These innovative technologies will dramatically increase safety and reliability and reduce the cost of space transportation.