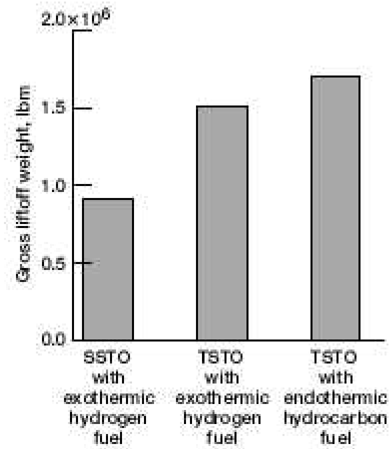
Advanced Fuels Can Reduce the Cost of Getting Into Space

Rocket propellant and propulsion technology improvements can reduce the development time and operational costs of new space vehicle programs, and advanced propellant technologies can make space vehicles safer and easier to operate, and can improve their performance. Five major areas have been identified for fruitful research: monopropellants, alternative hydrocarbons, gelled hydrogen, metallized gelled propellants, and high-energy-density propellants (ref. 1).

During the development of the NASA Advanced Space Transportation Plan, these technologies were identified as those most likely to be effective for new NASA vehicles. Several NASA research programs had fostered work in fuels under the topic *Fuels and Space Propellants for Reusable Launch Vehicles* (ref. 2) in 1996 to 1997. One component of this topic was to promote the development and commercialization of monopropellant rocket fuels, hypersonic fuels, and high-energy-density propellants. This research resulted in the teaming of small business with large industries, universities, and Government laboratories. This work is ongoing with seven contractors. The commercial products from these contracts will bolster advanced propellant research.

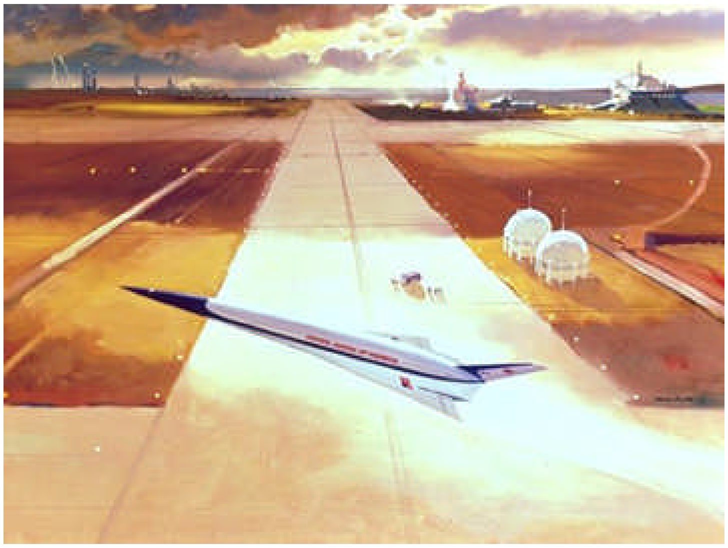
Work also is continuing under other programs, which were recently realigned under the "Three Pillars" of NASA: Global Civil Aviation, Revolutionary Technology Leaps, and Access to Space (ref. 3). One of the five areas is described below, and its applications and effect on future missions is discussed. This work is being conducted at the NASA Lewis Research Center with the assistance of the NASA Marshall Space Flight Center.

The regenerative cooling of spacecraft engines and other components can improve overall vehicle performance. Endothermic fuels can absorb energy from an engine nozzle and chamber and help to vaporize high-density fuel before it enters the combustion chamber (refs. 4 and 5). For supersonic and hypersonic aircraft, endothermic fuels can absorb the high heat fluxes created on the wing leading edges and other aerodynamically heated components. Dual-fuel options are also possible, where endothermic hydrocarbon fuels are used for the lower speed portions of flight below Mach 8, and hydrogen fuel is used for the final acceleration to the upper stage separation velocity.



Endothermic fuels increase gross liftoff weight but simplify operations for both single-stage-to-orbit (SSTO) and two-stage-to-orbit (TSTO) vehicles.

This bar graph shows the gross liftoff weight for several airbreathing space vehicles (ref. 1). The baseline case is a hydrogen-fueled single-stage-to-orbit vehicle, whose gross liftoff weight is less than 1 million lb. The gross liftoff weights of the two-stage-to-orbit vehicles are 1.5 and 1.7 million lb, respectively. Endothermic hydrocarbon fuels, because they absorb more heat, require an increased gross liftoff weight over hydrogen-fueled two-stage-to-orbit vehicles. However this increase in gross liftoff weight is relatively small at 0.2 million lb, and it eliminates the need for hydrogen for the first stage. Several types of related hydrocarbons can increase fuel density and reduce the overall mass of the vehicle structure, tankage, and related thermal protection systems.



Airbreathing orbital vehicle lifts off. This vehicle can use endothermic hydrocarbon fuel for part of its ascent to orbit.

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Programs/Projects: Global Civil Aviation, Revolutionary Technology Leaps, Access to Space, HEDS, MTPE, other programs involving propulsion