CENTAUR

FIRST IN SPACE WITH LIQUID HYDROGEN

NASA

CENTAUR PROGRAM

The objective of the Centaur Program is the exploration of the Moon prior to the landing of American astronauts. The Centaur launch vehicle will insert unmanned Surveyor spacecraft into precise translunar trajectories, enabling the instrumented research vehicles to soft-land (instruments remain in working order) at selected locations on the lunar surface. Later, Centaur will be used to launch unmanned spacecraft on missions to the near planets.

Centaur is a program of the Vehicle and Propulsion Programs Division of NASA's Office of Space Science and Applications. It is being developed by General Dynamics/Astronautics, under the direction of NASA's Lewis Research Center.

All Centaur launches at Cape Kennedy are supervised by Goddard Space Flight Center's Launch Operations Branch.

VEHICLE DESCRIPTION

Centaur is the first of a new generation of space vehicles to pioneer the use of liquid hydrogen for space flight. Liquid hydrogen is superior to previous or conventional rocket propellants because of its high energy yield compared to its weight.

The Centaur first stage is a modified Series D Atlas booster built by General Dynamics/Astronautics. It is similar to that used in such space missions as the Mariner 2 fly-by of Venus, the Ranger flights to the Moon, and Project Mercury, except that the tapered nose has been eliminated to accommodate the second stage. A 13-foot interstage adapter and separation system also have been added.

The first stage is powered by three Rocketdyne MA-5 engines and two small vernier rockets, which burn liquid oxygen and RP-1 (highly refined kerosene). These five engines are ignited simultaneously on the ground, and are gimbaled for directional control during the booster phase of the flight. Total lift-off thrust is 367,000 pounds.

The second stage (Centaur) is 43 feet in length and weighs approximately 35,000 pounds when fueled. It is powered by two Pratt & Whitney RL10A-3 liquid hydrogen-liquid oxygen engines that deliver 15,000 pounds of thrust each. These engines are capable of being shutdown and restarted during flight to increase mission flexibility.

Small hydrogen peroxide rockets mounted on the periphery of the second stage provide additional thrust for propellant settling and attitude control during coast periods. The main engines are gimbaled for directional control after first stage separation.

The Atlas-Centaur has a constant diameter of 10 feet, an overall length of 113 feet, and weighs 300,000 pounds at launch. The vehicle has no internal structure, and is pressurized to maintain its shape.

Guidance during first and second stage flight is effected by the Centaur guidance system, which is mounted on the forward end of the Centaur stage. This guidance system, developed by Minneapolis-Honeywell, is all inertial (self-contained) and designed to accommodate both orbital and deep space missions.

Centaur is the first United States space vehicle with a digital computer as part of its guidance system. This compact computer, manufactured by Librascope, generates solutions to guidance problems while the vehicle is in flight, thereby freeing the vehicle from dependency on control signals from ground-tracking and data-processing stations.

The Atlas-Centaur is capable of lifting over 8,000 pounds of instrumented payload into near-Earth orbit, landing 2,300 pounds on the Moon, and boosting 1,300 pounds on an interplanetary trajectory.

LIQUID HYDROGEN

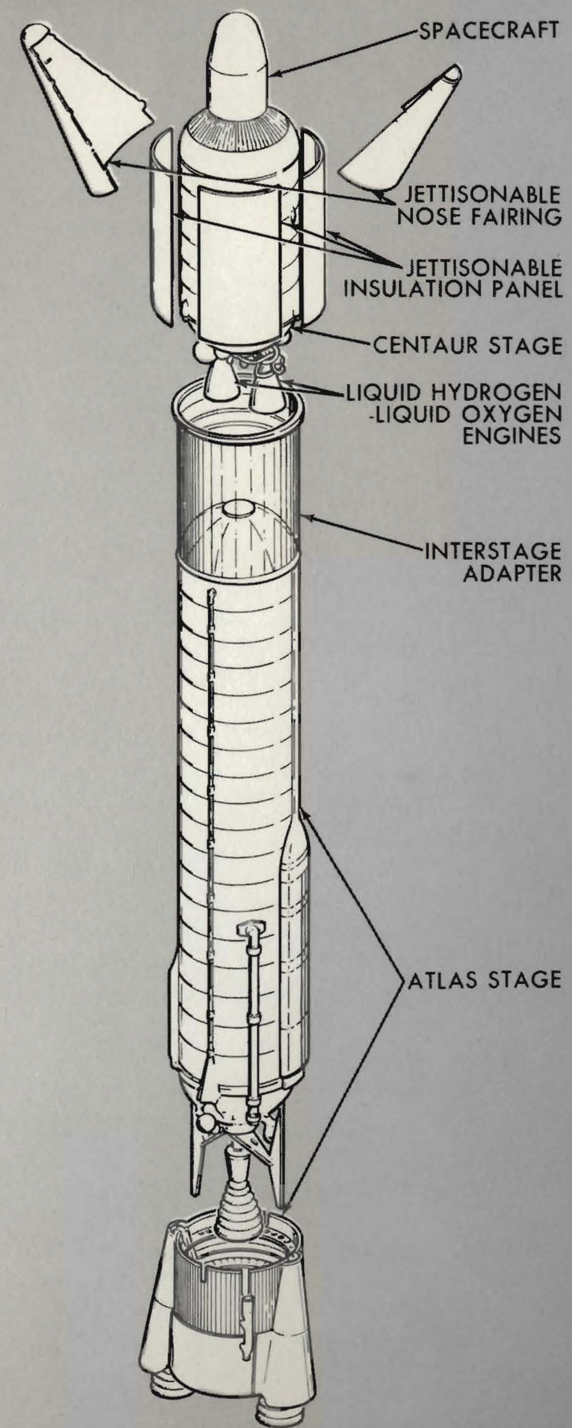
Hydrogen, the lightest and simplest of all elements, is known to exist in great quantities throughout the universe. The sun, for instance, uses hydrogen to fuel its vast thermonuclear furnace, which provides the light and heat to sustain life on this planet. On Earth, hydrogen is found in combination with other elements that form our water and many of our minerals.

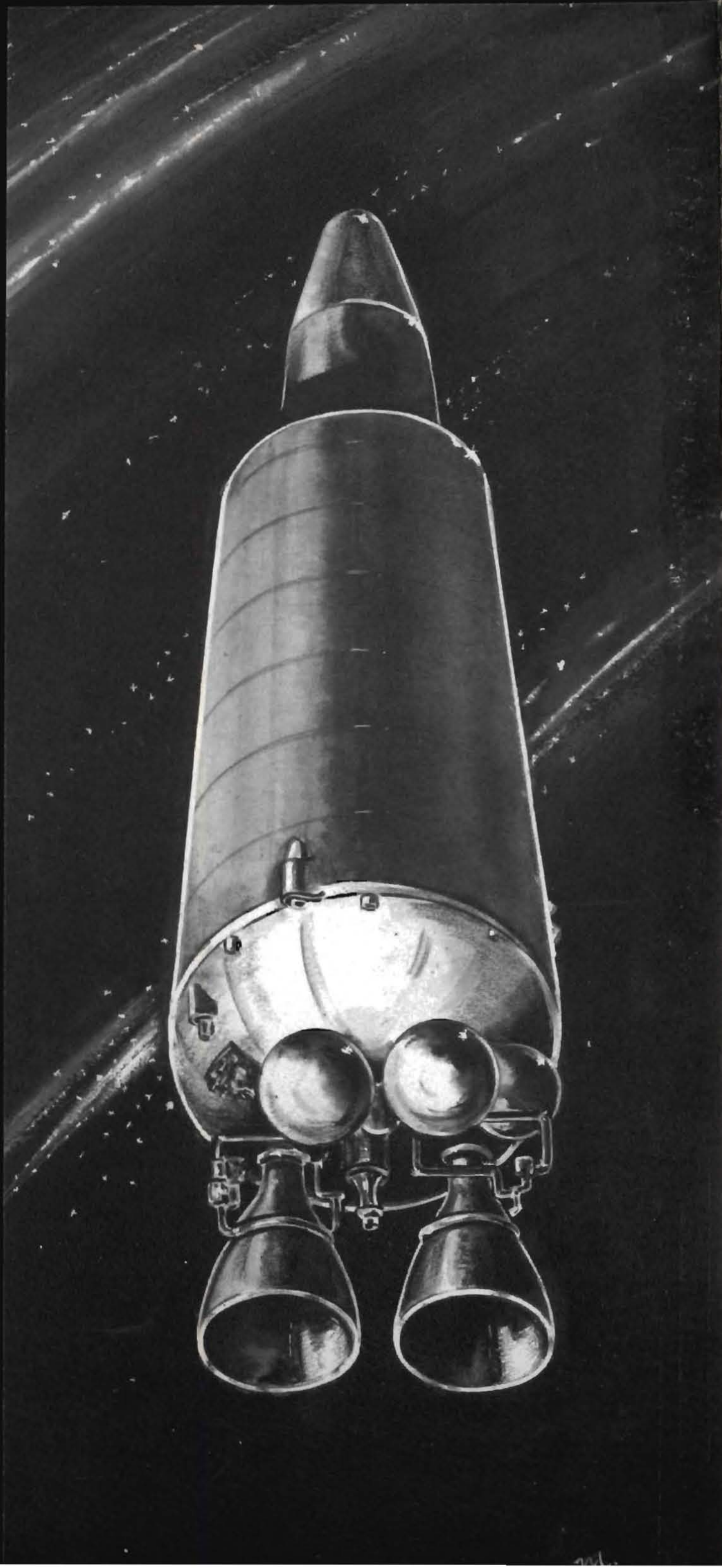
Hydrogen in its natural state is a gas. Because of its lighter-than-air properties, gaseous hydrogen was used in balloons during man's early attempts at flight. It fell into disuse when its explosive qualities became apparent, and was abandoned entirely as a flight medium with the fatal explosion of the dirigible Hindenburg in 1937.

As a liquid fuel for Centaur, hydrogen again has entered the flight scene. This time, however, sufficient research and development preceded its use, resulting in a brand new technology for handling, controlling, and utilizing hydrogen in its liquid form.

Liquid hydrogen is colorless, odorless, and very lightweight-only one-fourteenth as heavy as water. To remain in a liquid state, hydrogen must be kept supercooled to 423 degrees below zero. If "warmed" above that temperature, it vaporizes to gas. Mixed with liquid oxygen in a rocket engine, liquid hydrogen delivers about 35 per cent more thrust per pound of propellant consumed than conventional kerosene-type rocket fuels.

Since it is pioneering liquid hydrogen in flight, the Centaur Program will have a direct bearing on other NASA projects, including the use of liquid hydrogen as a propellant for the Saturn and Nova upper stages





SURVEYOR

The primary mission of Surveyor is to provide information vital to the landing of American astronauts on the Moon and their safe return to Earth.

The 2,100-pound spacecraft is designed to land on the Moon with its instruments intact and to take pictures of the Moon's surface, sample lunar soil, test for moonquakes, measure lunar gravity, and gather data on radiation, atmosphere, and magnetism. Information gathered by Surveyor will be transmitted to Earth via television and telemetry equipment aboard the spacecraft.

Jet Propulsion Laboratory has management responsibility for the Surveyor Program. The spacecraft is being built by Hughes Aircraft Co.

Surveyor not only will provide data necessary for manned lunar flight, but it also may make possible a significant scientific breakthrough in the search to understand the origin of the Moon and of the entire solar system.