

The Centaur Upper Stage

(Marshall H. Kaplan, Launchspace Contributor)

Bethesda – For those of you who are not familiar with the Centaur rocket and its history, this commentary should be of interest, especially on Centaur’s 50th anniversary. In Greek mythology, a “centaur” is a creature with the head, arms, and torso of a human and the body and legs of a horse. In the launch vehicle world, the Centaur concept is credited to Karel J. Bossart and Dr. Krafft A. Ehricke, both Convair employees in the 1950s. Their design was based on that of the Atlas ICBM. You might think of it as a smaller version of the ballistic missile that used lightweight stainless steel balloon-like tanks. Since the structure could not support its own weight, rigidity was provided by the pressure of the propellants within. To prevent the empty tanks from collapsing, they were either hung in a stretch position or pressurized with nitrogen gas.

However, the Centaur rocket stage was not intended to be a launch vehicle, but only a high-energy upper stage. Thus, Centaur functions as a booster to place satellites into orbits that may vary from near-Earth to geostationary transfer, or to interplanetary destinations. In fact, Centaur was the first high-energy upper stage that burned liquid hydrogen (LH2) and liquid oxygen (LOX).

Centaur boasted a unique tank design that used a common double-bulkhead to separate LOX and LH2 tanks. The two stainless steel skins were separated by a 6.4 mm layer of fiberglass honeycomb. Since LH2 is extremely cold it creates a vacuum within the fiberglass layer, giving the bulkhead low thermal conductivity that prevents heat transfer from relatively warm LOX to LH2.

Current versions of the Centaur are used on the Atlas V and Delta IV, and provide propellant to variants of the RL10 rocket engine. Centaur has survived the last five decades with its development beginning in 1956 at the NASA Lewis Research Center in Cleveland, later renamed the Glenn Research Center. The first test flight took place in May 1962, but was unsuccessful. Had the early tests been successful, Centaur may have been selected as the Saturn upper. However, lack of a successful launch history before 1965 led to NASA’s selection of a much larger stage for Saturn.



Finally, in 1965, Centaur did have its first flight success. From 1966 to 1989, the Centaur-D was used as the upper stage for 63 Atlas rocket launches, of which 55 were successful. From 1974 to 1977, the Centaur-D-1T was used as the third stage on seven Titan IIIE launches. Spacecraft launched by these vehicles included Viking 1 and 2, Voyager 1 and 2, and Helios 1 and 2.

Although Centaur has a long and successful history in space exploration, it has had its share of problems. Here are a few examples:

- May 8, 1962: Centaur's weather shield separated early causing a stage exploded.
- June 30, 1964: A RL-10 hydraulic actuator pump shaft broke, preventing one of the two RL-10 engines from vectoring.
- December 11, 1964: A restart attempt failed, due to problem with ullage rockets.
- May 9, 1971; Centaur guidance failed, destroying itself and the spacecraft bound for Mars.
- April 18, 1991: Centaur failed due to icing of hydrogen pump impeller blades.
- June 15, 2007: The engine in the Centaur upper stage of an Atlas V shut down early, leaving its payload in a lower than intended orbit.

Derivatives of the Centaur continue to be used as the upper stage of ULA's EELV launch vehicles.

To learn more about launch vehicle design and engineering, contact Launchspace Training.