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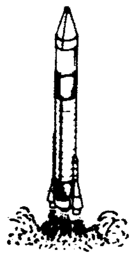

PROJECT: CENTAUR (AC-8)

(To be launched no earlier than March 29, 1966)

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CENTAUR DEVELOPMENT FLIGHT SCHEDULED FOR LAUNCH MARCH 29

The seventh Atlas-Centaur launch vehicle is scheduled for a development flight from Cape Kennedy no earlier that March 29.

Centaur is a hydrogen-fueled upper-stage combined with an Atlas booster, designed for high-energy lunar and planetary missions. The AC-6, launched Aug. 11, 1965, completed the first phase of its development effort and the vehicle. Centaur is now operational for direct-ascent Surveyor missions to the Moon.

Purpose of this mission, designated Atlas-Centaur 8 (AC-8), is to demonstrate Centaur's capability to restart its high-energy engines in the space environment following a coast period in Earth orbit, or an indirect ascent.

If the coming test is successful, NASA's first operational mission using the Centaur is aimed at placing a Surveyor space-craft on the Moon. The first Surveyor is scheduled for the second quarter of this year.

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Atlas-Centaur vehicles also have been selected to launch Mariner spacecraft on Mars flybys during the 1969 launch opportunity.

The AC-8 vehicle will carry a mass model of the Surveyor spacecraft which will be injected on a simulated lunar transfer trajectory toward an "imaginary Moon" following a 25-minute coast period in Earth orbit. The mass model will not impact the Moon but will be placed in a highly elliptical Earth orbit, extending more than 500,000 miles into space.

Although the first Surveyor/Centaur lunar missions will be by direct-ascent, a single burn of Centaur's hydrogen engines will place Surveyor on a lunar trajectory, the high-energy propulsion system was designed to be capable of restarting in the space environment. Such a capability would permit use of Earth "parking orbits" which offer certain launch window advantages for lunar and planetary missions.

The Centaur program is directed by NASA's Office of Space Science and Applications (OSSA) and managed by NASA's Lewis Research Center, Cleveland. Centaur launches are conducted for Lewis, by NASA's Kennedy Space Center's Unmanned Launch Operations, Cape Kennedy.

(BACKGROUND AND TECHNICAL INFORMATION FOLLOWS)

MISSION DESCRIPTION

Test Objectives

The prime purpose of the AC-8 mission is to demonstrate the capability of the Centaur vehicle to place a spacecraft in a parking orbit, i.e.: restart Centaur's hydrogen-fueled engines following a coast phase in Earth orbit and place the spacecraft on a lunar trajectory.

Centaur's single-burn direct-ascent capability was successfully demonstrated during a test flight (AC-6) last August when a dynamic model of Surveyor was launched toward a target in space, also termed an imaginary Moon.

Guidance during the AC-6 mission was sufficiently accurate that, had a Surveyor spacecraft been directed to a landing on the Moon, a midcourse velocity correction of only 9.5 miles-per-hour, well within Surveyor's capability, would have been required for Surveyor to impact its target area. (Ranger spacecraft, after midcourse correction, landed just a few miles from the target area.) Without any velocity correction, the spacecraft would still have traveled the 240,000 miles to the Moon and landed within 280 miles of the target.

The liquid hydrogen must be "bottomed" in the Centaur so it is in the right position to assure that boil-off vapor (hydrogen gas) is vented rather than liquid hydrogen. Small ullage rockets exert enough thrust to maintain propellants in the proper location.

The restart capability provides greater flexibility in vehicle launch operations. Launch windows, which are limited periods during which lunar or planetary payloads must be launched to intercept the target, are widened by from minutes to hours.

Earth parking orbits would also permit Surveyor launches to be attempted during winter months, when lunar lighting conditions are unfavorable for direct-ascent trajectories.

A restart of the Centaur propulsion system was attempted as a bonus experiment during an earlier mission (AC-4) but failed because the hydrogen propellant was not properly settled in the bottom of the tank. Several modifications (see launch vehicle section) have been made to the AC-8 vehicle based on the analyses of data from the AC-4 mission.

This is a development flight; however, a number of development objectives have been proven during previous test missions. These include:

-- The use of high-energy propulsion systems. (The AC-2 flight in 1963 was the first known successful flight using hydrogen-oxygen propellants.)

-- Centaur's capability to place a lunar spacecraft on a direct-ascent trajectory to the Moon, well within a spacecraft's midcourse maneuver capability to insure an accurate landing.

-- Centaur's launch-on-time capability to meet narrow lunar and planetary launch windows.

-- Demonstration of the structural integrity of both Atlas and Centaur. (The Centaur second stage and its payload weigh about 40,000 pounds, by far the heaviest weight ever boosted by an Atlas.)

-- Successful demonstration of Centaur's all-inertial guidance system, i.e.: without command control from Earth.

-- Demonstration of the Centaur spacecraft separation system.

-- Demonstration of Centaur's Propellant Utilization System, which assures proper and maximum use of available propellants. (During its first flight test last August, the system error was less than five pounds out of the 30,000 pounds of propellant consumed during the flight.)

-- Demonstration of satisfactory performance of a number of subsystems, including propellant loading indicating system, hydraulic, pneumatic, electrical, and instrumentation, and in-flight insulation panel and nose fairing jettison systems.

Flight Plan

After liftoff, AC-8 will rise vertically for the first 15 seconds, then roll from a launcher heading of 115 degrees to a flight plane azimuth of 103 degrees. During boos er engine flight, the vehicle is steered by the Atlas autopilot.

After about 140 seconds of booster flight, the booster engines are shutdown (BECO) and jettisoned. The Centaur guidance system then takes over flight control. The Atlas sustainer engine continues to propel the AC-8 vehicle to an altitude of about 88 miles. Prior to sustainer engine shutdown, the second stage insulation panels, which prevent excessive hydrogen boiloff, are jettisoned, followed by the nose fairings, which protect the payload.

The Atlas and Centaur stages are then separated by an explosive, shaped charge and retrorockets mounted on the Atlas.

Centaur's hydrogen engines are then ignited for a planned 325-second burn. This will place Centaur and the Surveyor mass model into a 100-mile Earth parking orbit.

As Centaur's engines are shut down and the coast phase begins, two 50 pound thrust hydrogen-peroxide rockets are fired for about 100 seconds to settle the propellants because the vehicle is in a weightless condition.

Two hydrogen-peroxide ullage rockets, each with three pounds thrust, are then fired to retain the propellants in the lower part of the tanks.

During the approximate 25-minute coast period in Earth orbit, control of Centaur will be accomplished using two clusters of 3.5 and 6 pound thrust hydrogen-peroxide rockets.

About 46 seconds before Centaur's second burn, two 50 pound thrusters are again used to ensure proper propellant settling.

Once Centaur is in an accurate position to inject the Surveyor model toward its "imaginary Moon," the hydrogen-fueled engines are ignited for an approximate 107-second burn. The second-burn command and duration of the burn are determined by Centaur's inertial guidance system, as are all command and steering functions following Atlas booster engine cutoff and jettison.

The Surveyor mass model is separated from Centaur and injected toward its target in space -- a hypothetical Moon about 236,000 statute miles from Earth.

Following spacecraft separation, the Centaur vehicle will perform a 180-degree reorientation maneuver, using its attitude control system and two 50 pound thrusters. This alters Centaur's trajectory and places it in a position to perform a retromaneuver. During the retromaneuver residual propellants are "blown" through Centaur's engines to move the vehicle away from the Surveyor model.

On an operational mission, the retromaneuver will prevent Surveyor's star seeker frommistaking the Centaur vehicle for Canopus, the star on which Surveyor will focus for orientation.

Thus, five hours after launch Centaur and the model will be separated by at least 200 statute miles. The model will continue into a highly elliptical Earth orbit extending more than 500,000 miles into space and circling the Earth once every 37 days. Centaur's apogee will be about 385,000 miles, perigee 100 miles, and it will orbit the Earth each 21 days.

Orbital inclination to the equator of both Centaur and the mass model is expected to be 30.8 degrees.

LAUNCH VEHICLE

(All figures approximate)

Liftoff weight:	300,000 lbs.
Liftoff height:	113 feet
Launch Complex:	36-B
Launch time:	daylight hours (9 a.m. - 4 p.m., EST)

	Atlas-D Booster	Centaur Stage
Weight	260,000 lbs.	40,000 lbs.
Height	75 feet (including interstage adapter)	48 feet (with fairing)
Thrust	389,000 lbs. (sea level)	30,000 lbs. at altitude
Propellants	Liquid oxygen and RP-1	Liquid hydrogen and liquid oxygen
Propulsion	MA-5 system (2-165,000 lb. thrust engines, 1-57,000, 2-1,000)	Two RL-10 engines
Velocity	5,500 mph at BECO 7,900 mph at SECO	23,600 mph at injection
Guidance	Pre-programmed auto-pilot through BECO	Inertial guidance

AC-8 consists of a modified Series D Atlas combined with a Centaur second stage. Both stages are 10 feet in diameter and are connected by an interstage adapter. Both the Atlas and Centaur maintain their correct shape through pressurization.

The Atlas first stage is 75 feet high, including the interstage adapter, and uses a standard MA-5 propulsion system. It consists of two booster engines and a sustainer engine, developing 387,000 pounds of thrust. Two vernier engines of 1,000 pounds thrust each provide roll directional control.

The Centaur second stage including the nose fairing, is 48 feet long. It is powered by two improved RL-10 hydrogen-oxygen engines, designated RL-10-A-3-3. The RL-10 was the first hydrogen-fueled engine developed for the space program and is the forerunner of the larger J-2 and M-1 hydrogen engines, which develop 200,000 and 1,500,000 pounds thrust, respectively.

Recent modification of the RL-10 includes increasing the area ratio of the nozzle. The resulting increase in specific inpulse added about 200 pounds to Centaur's lunar payload capability.

The current Atlas-Centaur vehicle can launch over 2,250 pounds on a lunar trajectory or send 1,300-pound payloads to Venus and Mars.

Centaur carries insulation panels and a nose fairing which are jettisoned after the vehicle leaves the Earth's atmosphere. The insulation panels, weighing a total of about 1,200 pounds, surround the second stage hydrogen tank to prevent the heat of air friction from causing excessive boil-off of liquid hydrogen during flight through the atmosphere. The nose fairing protects the payload from this same heat environment.

Several modifications have been made to the Atlas-Centaur vehicle for the AC-8 flight. All pertain to problems associated with two-burn missions. Major changes are:

--Redesign of the hydrogen venting system. Since venting of hydrogen -- particularly liquid instead of gas -- created an unbalanced propulsion force on the AC-4 vehicle and resulted in an uncontrollable tumbling condition, the hydrogen vent system has been redesigned to permit venting outward from both sides of the Centaur stage during weightless flight, maintaining a balanced force.

--Uprating the attitude control engines. AC-8 will employ four 3.5-pound and two 6-pound thrust hydrogen-peroxide engines for attitude control. These thrusters will provide increased force for maintaining proper vehicle orientation during the coast phase.

--Addition of devices to the hydrogen boost-pump-bleed and recirculation lines to minimize disturbances in the IH_2 tank. Centaur employs boost pumps to increase the rate of flow of propellants. Some of the propellants, however, are "bled" off and recirculated, back to the fuel tank to prevent pump "cavitation", or gas formation in the pump. The recirculation line is designed to avoid a similar condition in the engines by prechilling the propellant feed lines.

--Addition of a hydrogen tank slosh baffle assembly. This system, together with the 50-pound thrusters and system modifications mentioned earlier, is designed to minimize disturbances in the LH_2 tank during weightlessness so the propellants will be in proper location at the pump inlet for engine restart.

All of these modifications are interrelated and their primary purpose is to insure that propellants are "settled" during weightlessness and available at the bottom of the tank when needed for engine restart.

Centaur's inertial guidance system consists of an inertial platform, digital computer and associated electronics. The system, located on the Centaur stage, will generate pitch and yaw steering signals to the auto-pilots for flight control from booster engine cutoff (BECO) plus eight seconds, to termination of the Centaur retromaneuver.

Mass Model

The 1,700-pound mass model which AC-8 will carry does not resemble a Surveyor spacecraft in appearance but is ballasted to simulate Surveyor's retrorocket and solar panel/planar array antenna assemblies. The model also will be equipped with an S-band transponder to permit post-separation tracking.

The model is made for in-flight separation using an operational-type Surveyor separation system, which was used successfully during the AC-6 mission last summer.

No telemetry instrumentation is installed on the model, but some payload-associated measurements are provided on the spacecraft adapter.

Instrumentation and Tracking

AC-8 will be heavily instrumented. Telemetry will radio data measurements from the Centaur stage prior to launch and through spacecraft separation for about three hours, or until its battery power is depleted.

Measurements on the Centaur stage will send information on engine behavior. Also, due to the importance of propellant behavior during the Centaur coast phase, about 100 sensors will send information on propellant motions in the LH_2 tank throughout the flight.

Booster stage data will relate primarily to engine functions and flight control systems, plus standard vibration, structural bending and temperature information.

The Surveyor mass model will be instrumented to measure temperatures around the spacecraft adapter and pressure and vibration levels at the top of the antenna assembly.

AC-8 will be tracked during powered flight and portions of its orbital flight to obtain performance information.

Atlas-Centaur powered flight tracking down the Eastern Test Range will be accomplished by C-band radar and Azusa Mark II/ Glotrac systems by stations at Cape Kennedy, Antigua, Grand Bahama, San Salvador and Bermuda.

During the coast phase prior to the Centaur second burn, data reception and tracking will be by Antigua, telemetry ships in the South Atlantic, Ascension Island and Pretoria, South Africa. The South African station is expected to confirm Centaur second burn, engine shut down and spacecraft separation.

Following injection into orbit, an S-band transponder attached to the mass model will be tracked by stations of NASA's Deep Space Network for about 20 hours.

Additional precision tracking data on Centaur and the model will be supplied by the Smithsonian Astrophysical Observatory's worldwide network of Baker-Nunn cameras.

CENTAUR PROJECT TEAM

The Centaur program is under the overall direction of NASA's Office of Space Science and Applications. Dr. Homer E. Newell is Associate Administrator of NASA. Vincent L. Johnson is director, launch vehicle and propulsion programs and R. D. Ginter is Centaur program manager.

Project management is under NASA's Lewis Research Center, Dr. Abe Silverstein is director of Lewis. Bruce T. Lundin, is associate director for development and Edmund R. Jonash is Centaur project manager.

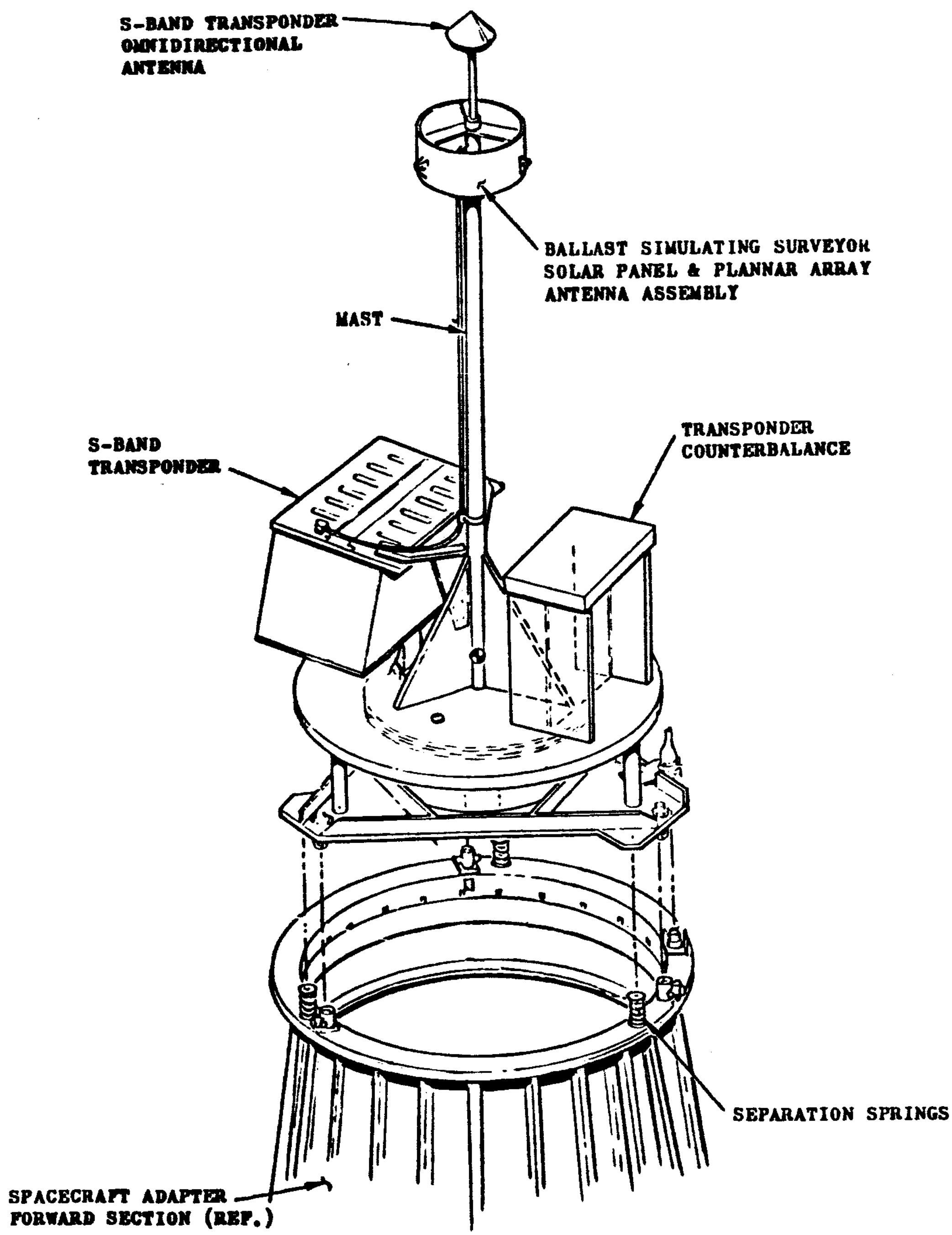
Centaur launches are conducted for Lewis by John F. Kennedy Space Center's Unmanned Launch Operations. Robert Gray is assistant director for unmanned launch operations, KSC. John Gossett is the Centaur operations manager.

Convair Division of General Dynamics Corp., San Diego, is prime contractor for the Centaur vehicle, including the Atlas booster. Grant L. Hansen, vice president, launch vehicle programs, is responsible for the Atlas-Centaur program. (Convair also designed and built the AC-8 mass model.)

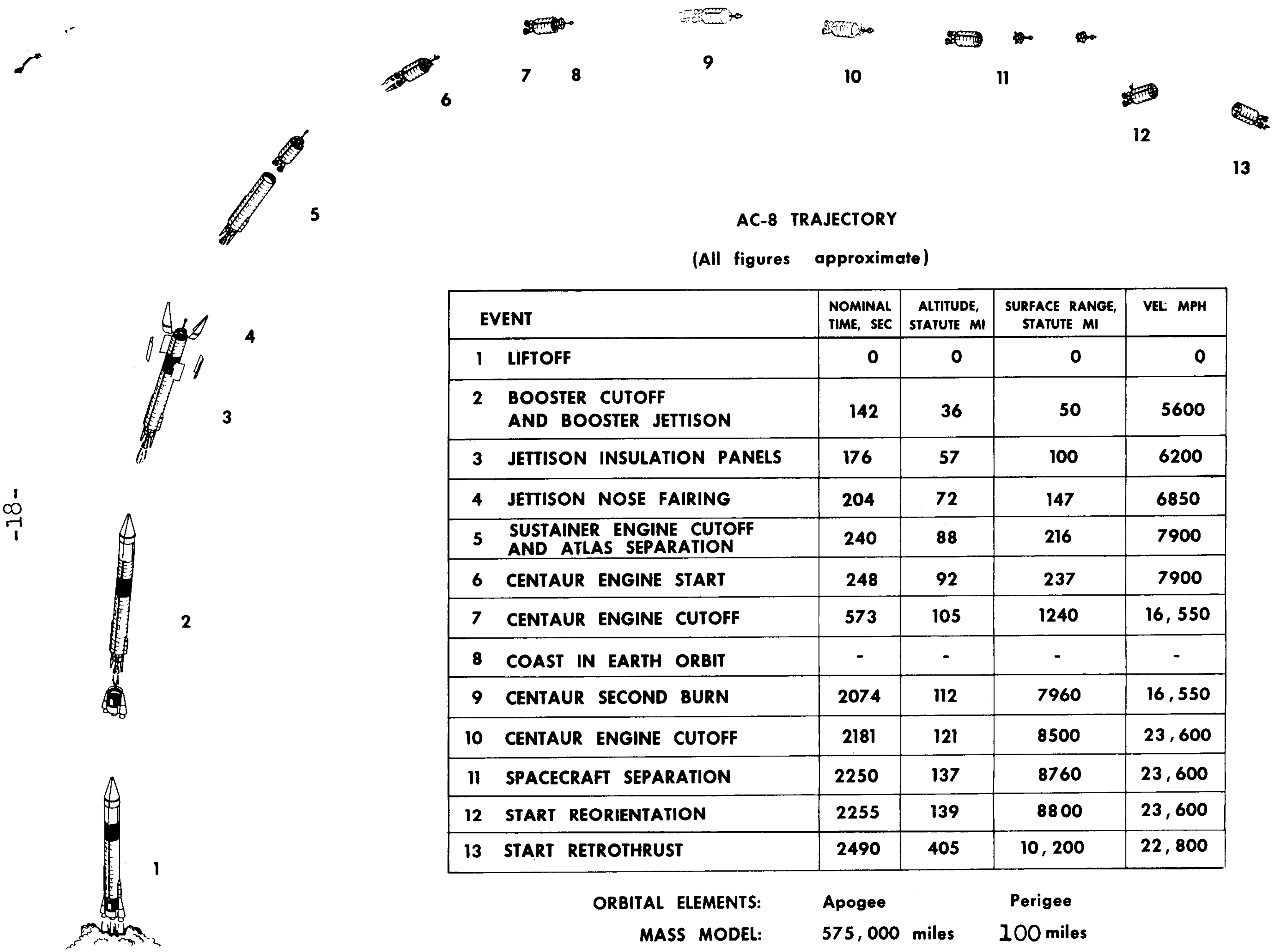
Pratt and Whitney Aircraft Div. of United Aircraft Corp., West Palm Beach, Fla., is an associate prime contractor for Centaur's hydrogen-oxygen engines. Richard Anchutze is P&W's RL-10 project manager. (This contract is managed by NASA's Marshall Space Flight Center, Huntsville, Alabama.)

Honeywell Inc., St. Petersburg, Fla., is an associate prime contractor for Centaur's inertial guidance system. R.B. Foster is program manager.

Several hundred other U.S. contractors are involved in the Centaur development program.



General Arrangement of Surveyor Mass Model



AC-8 TRAJECTORY

(All figures approximate)

EVENT	NOMINAL TIME, SEC	ALTITUDE, STATUTE MI	SURFACE RANGE, STATUTE MI	VEL MPH
1 LIFTOFF	0	0	0	0
2 BOOSTER CUTOFF AND BOOSTER JETTISON	142	36	50	5600
3 JETTISON INSULATION PANELS	176	57	100	6200
4 JETTISON NOSE FAIRING	204	72	147	6850
5 SUSTAINER ENGINE CUTOFF AND ATLAS SEPARATION	240	88	216	7900
6 CENTAUR ENGINE START	248	92	237	7900
7 CENTAUR ENGINE CUTOFF	573	105	1240	16, 550
8 COAST IN EARTH ORBIT	-	-	-	-
9 CENTAUR SECOND BURN	2074	112	7960	16,550
10 CENTAUR ENGINE CUTOFF	2181	121	8500	23,600
11 SPACECRAFT SEPARATION	2250	137	8760	23,600
12 START REORIENTATION	2255	139	8800	23,600
13 START RETROTHRUST	2490	405	10, 200	22,800

ORBITAL ELEMENTS:	Apogee	Perigee
MASS MODEL:	575,000 miles	100 miles
CENTAUR:	385,000 miles	100 miles