APOLLO FLIGHT TESTS

The Apollo flight test program up to September, 1968, included space tests of four command and service modules, one lunar module, and space and atmospheric tests of 10 boilerplate (test) command and service modules. These tests were conducted under the "all-up" philosophy of testing as many things simultaneously as possible and thus minimizing the number of launches, as well as cost and time.

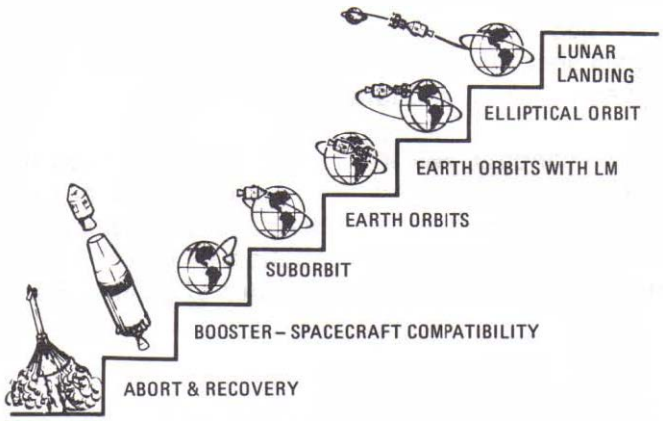
The program is aimed at designing the spacecraft so that all launches contribute to its development. The command and service modules are being developed separately from the lunar module; this permits both modules to be tested on the smaller Saturn IB launch vehicle. The test program depends on the Saturn V only for missions that require its large payload.

Another test program goal has been maximum development on the ground; space flights have been undertaken only with spacecraft with almost all systems aboard and operating.

An example of this philosophy of combining many tests on one flight was the Apollo 6 mission on April 4, 1968. This mission included the second flight of a Saturn V launch vehicle as well as a number of important spacecraft tests.

Although launch vehicle problems caused selection of an alternate mission and prevented achievement of some major objectives, NASA termed the spacecraft's accomplishments impressive. These included the longest single burn in space of the service propulsion engine (7 minutes, 25 seconds), proper control of the engine during this burn by the guidance and navigation subsystem, proper maintenance of spacecraft attitude by the reaction control subsystem during the long cold soak period, and another successful test of the spacecraft's heat shield. This also was the first space test of the new unified crew hatch and seals and they withstood the mission in good condition.

The first flight of the Saturn V was on Nov. 9, 1967, in the Apollo 4 mission, which also was a major test of the CM's heat shield, service propulsion subsystem, guidance and navigation equipment, and environmental control subsystem. The major objectives of Apollo 4, all fulfilled, were: the first launch of the Saturn V first stage, the first



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flight of the hydrogen-powered second stage, restart of the third stage in earth orbit, restart of the service propulsion engine in space and its record firing for nearly 5 minutes, a hot and cold soak of the spacecraft far out in space, and entry under the severest conditions yet encountered by a spacecraft (a velocity of 24,913 miles per hour and a heat shield temperature of about 5,000 degrees F).

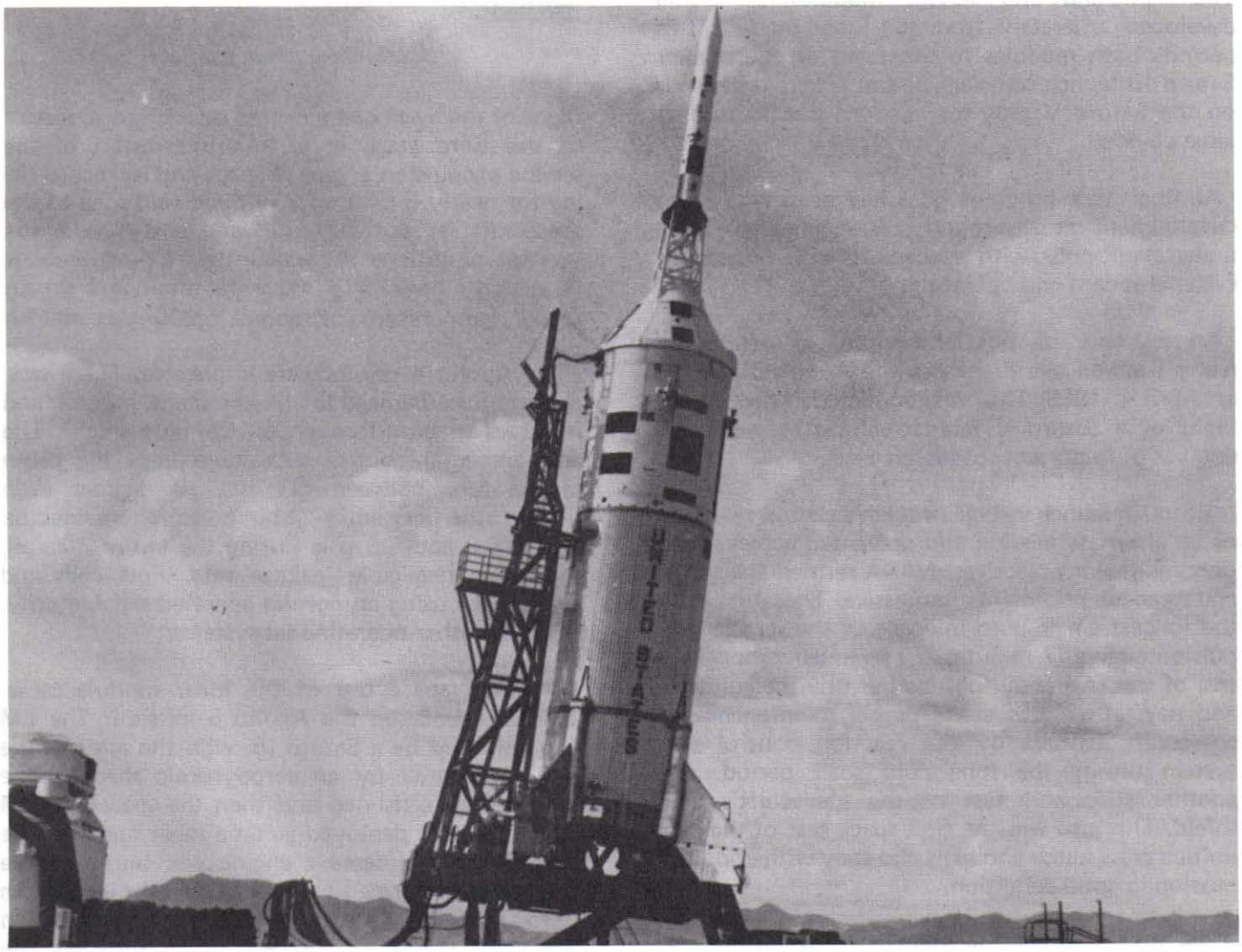
The Apollo 4 results were impressive. There was no structural damage to the command module and no areas of burn-through on the heat shield. The environmental control subsystem kept the cabin temperature between 60 and 70 degrees even through the fiery entry. Cabin pressure remained between 5.6 and 5.8 psia during the entire mission, indicating negligible leakage rate. Fuel cells and subsystems using cryogenics operated satisfactorily, as did all other operating subsystems.

The first space test of the lunar module came Jan. 22, 1968, on the Apollo 5 mission. The LM was launched by a Saturn IB, with the apex of the vehicle covered by an aerodynamic shroud. The shroud was jettisoned and then the spacecraft-LM adapter panels deployed as on a lunar mission. The lunar module's descent engine was burned three times and performed as expected. At the end of the third burn, a "fire-in-the-hole" abort—in which the LM's ascent and descent stages separate, the ascent engine begins to burn and simultaneously the descent engine stops firing—was performed successfully. A second ascent engine burn was performed later in the mission. Data telemetered to the ground indicated that all other subsystems of the module operated satisfactorily.

The Apollo 4, 5, and 6 missions were part of the earth-orbital phase of the flight test program. (There were no Apollo 1, 2, or 3 missions.) The program is divided into two blocks with interrelated phases: launch abort, sub-orbital, and earth-orbital (Block I) and earth-orbital and lunar (Block II).

For economy, boilerplate spacecraft are used in the program where an actual spacecraft is not required. Boilerplates are research and development vehicles that simulate production modules in size, shape, structure, mass, and center of gravity. Each boilerplate has instruments to record data for engineering evaluation.

The sub-orbital flights tested the heat shield and the operation of subsystems. The earth-orbital portion of the flight test program tests further the operational abilities of subsystems, the Saturn I, the Saturn IB, and Saturn V operation and compatibility, and operations during earth orbit, and also develops qualified teams for checkout, launch, flight operations, mission support, recovery, and flight analysis.



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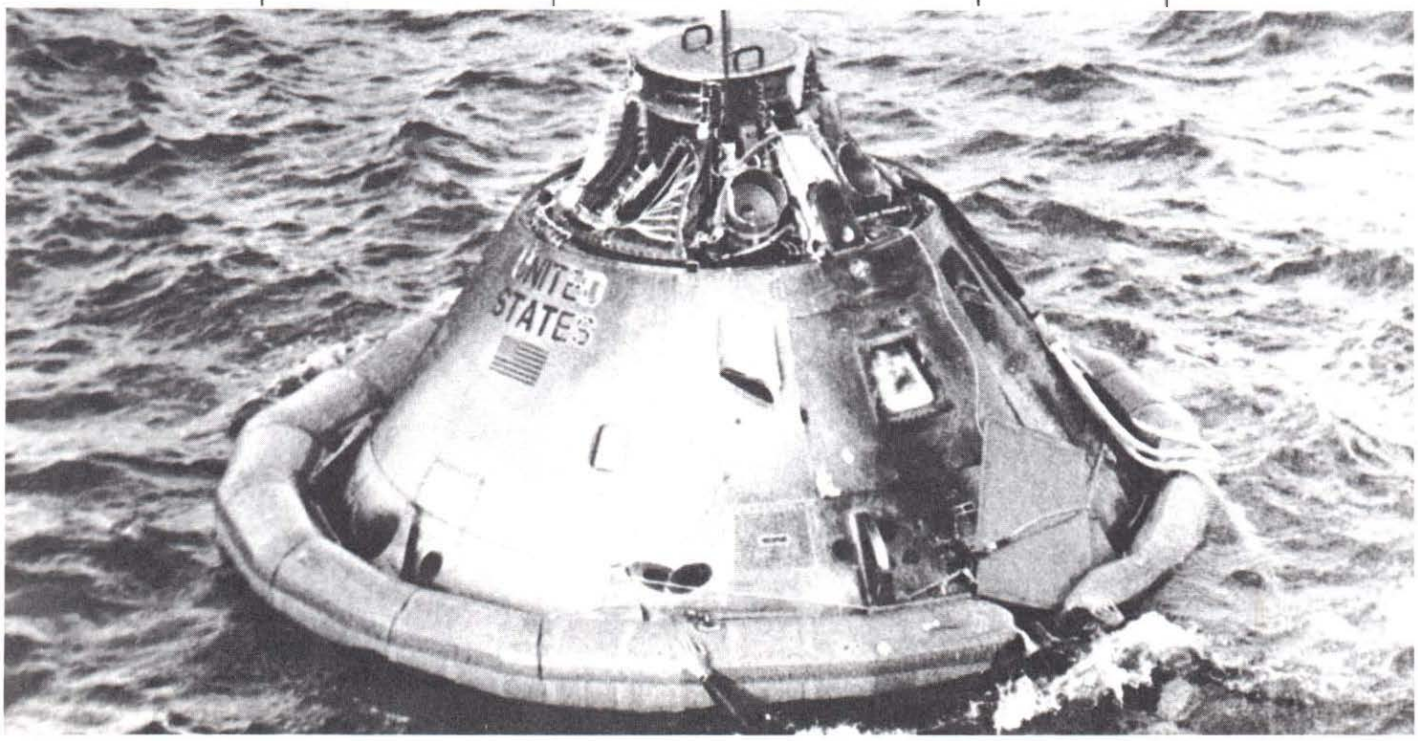
Command and service modules mounted on Little Joe II booster at White Sands, N.M., for test of launch escape subsystem

APOLLO FLIGHT TESTS

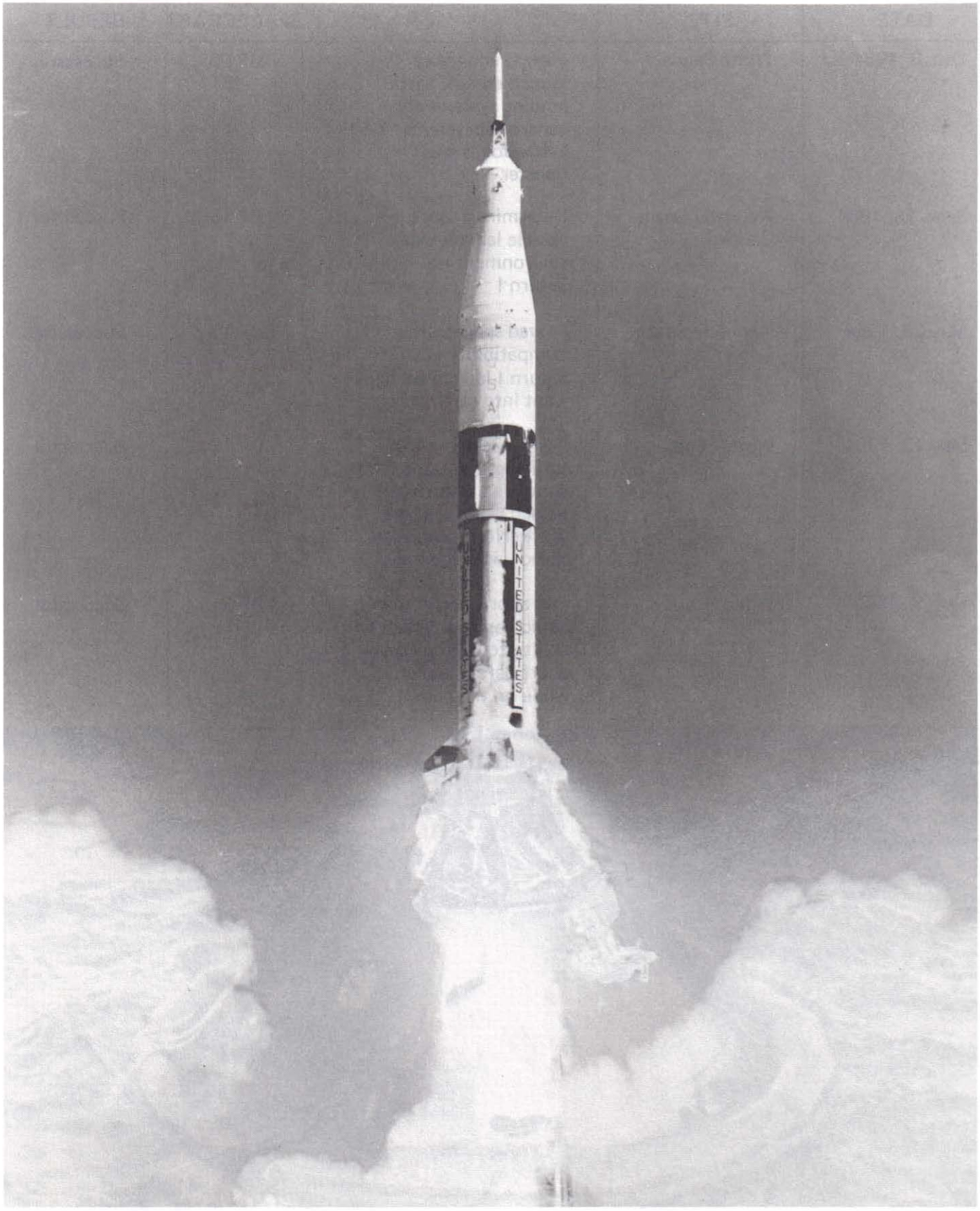
DATE	SITE		SPACECRAFT	RESULT
Apr. 4, 1968	Kennedy Space Center	Apollo 6: Second flight of Saturn V; launch vehicle engine problems caused spacecraft to go into alternate mission; service propulsion engine burned for record length, other subsystems performed well	SC020	Partial success
Jan. 22, 1968	Kennedy Space Center	Apollo 5: First space flight of lunar module; tested ascent and descent engines and ability to abort lunar landing and return to orbit; Saturn IB was launch vehicle	LM-1	Successful
Nov. 9, 1967	Kennedy Space Center	Apollo 4: First Saturn V launch; spacecraft entered atmosphere at almost 25,000 mph; heat shield temperatures reached about 5000°F; first test at lunar return speed	SC017	Successful
Aug. 25, 1966	Kennedy Space Center	Second flight of unmanned Apollo spacecraft to test command module's ability to withstand entry temperatures under high heat load; Saturn IB was launch vehicle	SC011	Successful
Feb. 26, 1966	Kennedy Space Center	First flight of unmanned Apollo spacecraft to test command module's ability to withstand entry temperatures; determine CM's adequacy for manned entry from low orbit test CM and SM reaction control engines and test service propulsion engine firing and restart; this was also first flight of the Saturn IB	SC009	Successful (Service module engine produced slightly less thrust than expected, resulting in slightly lower reentry speed and temperatures.)

DATE	SITE		SPACECRAFT	RESULT
Jan. 20, 1966	White Sands	Final abort test utilizing actual spacecraft to test escape in high tumbling region; this completed the abort test phase, qualifying the astronaut escape system for manned flights; Little Joe II was booster	SC002	Successful
July 30, 1965	Kennedy Space Center	Third Pegasus meteoroid detection satellite; launched by Saturn I; Apollo spacecraft shell and spacecraft-LM adapter housed and protected the Pegasus payload until reaching orbit where SLA panels opened, permitting the satellite to deploy	BP 9A	Successful
June 29, 1965	White Sands	Pad abort: Second test of the launch escape system's ability to work in emergency before launch and while still on the pad; canards, boost protective cover, jettisonable apex cover, and dual reefed drogue chutes were tested	BP 23A	Successful
May 25, 1965	Kennedy Space Center	Second Pegasus meteoroid detection satellite; Saturn I was launch vehicle	BP 26	Successful
May 19, 1965	White Sands	Planned high-altitude launch escape system test to determine performance of launch escape vehicle canard subsystem, and to demonstrate orientation of launch escape vehicle (Little Joe II)	BP 22	Partially successful (boost vehicle guidance malfunctioned causing premature low-altitude abort; Apollo systems functioned perfectly, pulling command module away from debris and lowering it safely to earth)
Feb. 16, 1965	Kennedy Space Center	First Pegasus micrometeoroid detection satellite; Saturn I was launch vehicle	BP 16	Successful

DATE	SITE		SPACECRAFT	RESULT
Dec. 8, 1964	White Sands	High Q abort test launch escape, earth landing systems and canard subsystems; Little Joe II was booster	BP 23	Successful
Sept. 18, 1964	Kennedy Space Center	Determined space vehicle launch exit environment on Saturn I	BP 15	Successful
May 28, 1964	Kennedy Space Center	Proved spacecraft compatibility with Saturn I launch vehicle; went into earth orbit	BP 13	Successful
May 13, 1964	White Sands	Transonic abort test utilizing Little Joe II to simulate a Saturn V launch vehicle; abort was performed at high speed with high loads	BP 12	Successful
Nov. 7, 1963	White Sands	Pad abort; tested the launch escape system's ability to perform an abort before launch while on the pad	BP 6	Successful



Recovery of first unmanned Apollo spacecraft by U.S.S. Boxer Feb. 26, 1966 in South Atlantic following launch by Saturn IB. During suborbital flight, spacecraft traveled 300 miles up.



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Saturn IB lifts CSM off pad on early Apollo flight test