TESTING

INTRODUCTION

The expense of the Saturn V makes it imperative that no effort be spared to assure that it will perform as expected in flight. The magnitude of the Saturn V ground test program, therefore, is unprecedented. To qualify for flight, all components and systems must meet standards deliberately set much higher than actually required. This margin of safety is built into all manrated space hardware.

Compared with earlier rocket programs the ground testing on Saturn V is more extensive and the flight testing is shorter. The ground test programs conducted on the F-1 and J-2 engines, which power the three stages, offer an example of the thoroughness of this testing effort. The J-2 has been fired some 3,500 times on the ground, for a total running time of more than 97 hours. During flight of five Saturn IB and two Saturn V launch vehicles, 17 J-2 engines operated a total time of almost two hours. The F-1 has been fired more than 2,772 times for a running time of more than 64 hours. On two Saturn V launches ten F-1 engines have run for a total of about 25 minutes.

Further, in earlier rocket programs such as Redstone, Thor, and Jupiter, 30 to 40 R&D flight tests were standard. In the Saturn I program,where more emphasis was placed on ground testing prior to the flight phase, 10 R&D flight tests were planned. The vehicle was declared operational after the first six firings met with success.

The Saturn IB—an improvement on the basic Saturn I—was manrated after three flights. On the Saturn V, only two flights are planned prior to the attainment of a "manned configuration."

The inspection to which flight hardware is subjected is thorough. Following are examples of many steps which are taken to inspect the Saturn V vehicle:

1. X-rays are used to scan fusion welds, 100 castings, and 5,000 transistors and diodes.
2. A quarter mile of welding and 5 miles of tubing are inspected with the use of a sound technique (ultrasonics). The same type of inspection is given to adhesive bonds, which are equivalent in area to an acre.
3. An electrical current inspection method is used on 6 miles of tubing, and dye penetrant tests are run on 2.5 miles of welding.

Each contractor has his own test program patterned to a rather basic conservative approach. It begins with research to verify specific principles to be applied and materials to be used. After production starts each contractor puts flight hardware through qualification testing, reliability testing, development testing, acceptance testing, and flight testing.

QUALIFICATION TESTING

Qualification testing of parts, subassemblies, and assemblies is performed to assure that they are capable of meeting flight requirements. Tests under the conditions of vibration, high-intensity sound, heat, and cold are included.

RELIABILITY TESTING

Reliability analysis is conducted on rocket parts and assemblies to determine the range of failures or margins of error in each component. Reliability information is gathered and shared by the rocket industry.

DEVELOPMENT TESTING

A battleship test stage constructed more solidly than a flight stage is often used to prove major design parameters within a stage. Such a vehicle verifies propellant loading, tank and feed operation, and engine firing techniques.

Battleship testing is followed by all-systems testing. For example, one of four ground test stages of the first stage completed 15 firings at Marshall Space Flight Center in Huntsville. The firings proved that the design and fabrication of the complete booster and of its subsystems were adequate.

The entire Apollo/Saturn V vehicle, consisting of the three Saturn V propulsive stages, the instrument unit, and an Apollo spacecraft, was assembled in the Dynamic Test Stand at the Marshall Center. This is the only place, aside from the launch site, where the entire Saturn V vehicle has been assembled. The purpose of dynamic testing was to determine the bending and vibration characteristics of the vehicle to verify the control system design. The 363-foot assembly was placed on a hydraulic bearing or "floating platform". Electromechanical shakers caused the vehicle to vibrate, simulating the response expected from flight forces.

ACCEPTANCE TESTING

Finished work undergoes functional checkout to insure it meets operational requirements. Tests range from continuity and compatibility of wiring to all-systems ground testing. Fluid-carrying components are subjected to pressures beyond normal operating requirements, and structural components receive visual and X-ray inspections. Instruments simulate flight conditions to evaluate total performance of electrical and mechanical equipment.

Rocket engines are static-fired before delivery to the stage contractor. Such tests demonstrate performance under conditions simulating flight temperatures, pressures, vibrations, etc.

Each flight stage completes a series of systems tests which lead to a full-power, captive acceptance firing. Afterwards it is refurbished and given a postfiring checkout before going to Kennedy Space Center.

AUTOMATIC CHECKOUT

A fully automated, computer-controlled vehicle checkout has been designed into all major segments of the Saturn V for extensive stage test operations.

Automatic checkout is used first in the final factory checkout and then throughout prefiring preparations for static tests and during the actual countdown for these firings. It is employed again throughout the postfiring checkout and finally for prelaunch checkout and launch operations at Kennedy Space Center.

The sytem uses a carefully detailed computer program and associated electronic equipment to perform the complete countdown of each Saturn stage.

With electronic speed, the automatic checkout moves through a precisely controlled and repeatable checkout test program. The system performs a point-by-point test of each function, indicates responses to tests, and pin-points any malfunction that occurs. The automatic checkout can also indicate ways to double check a questionable response in order to define any difficulty. It virtually eliminates the possibility of human error during a countdown.

FLIGHT TESTING

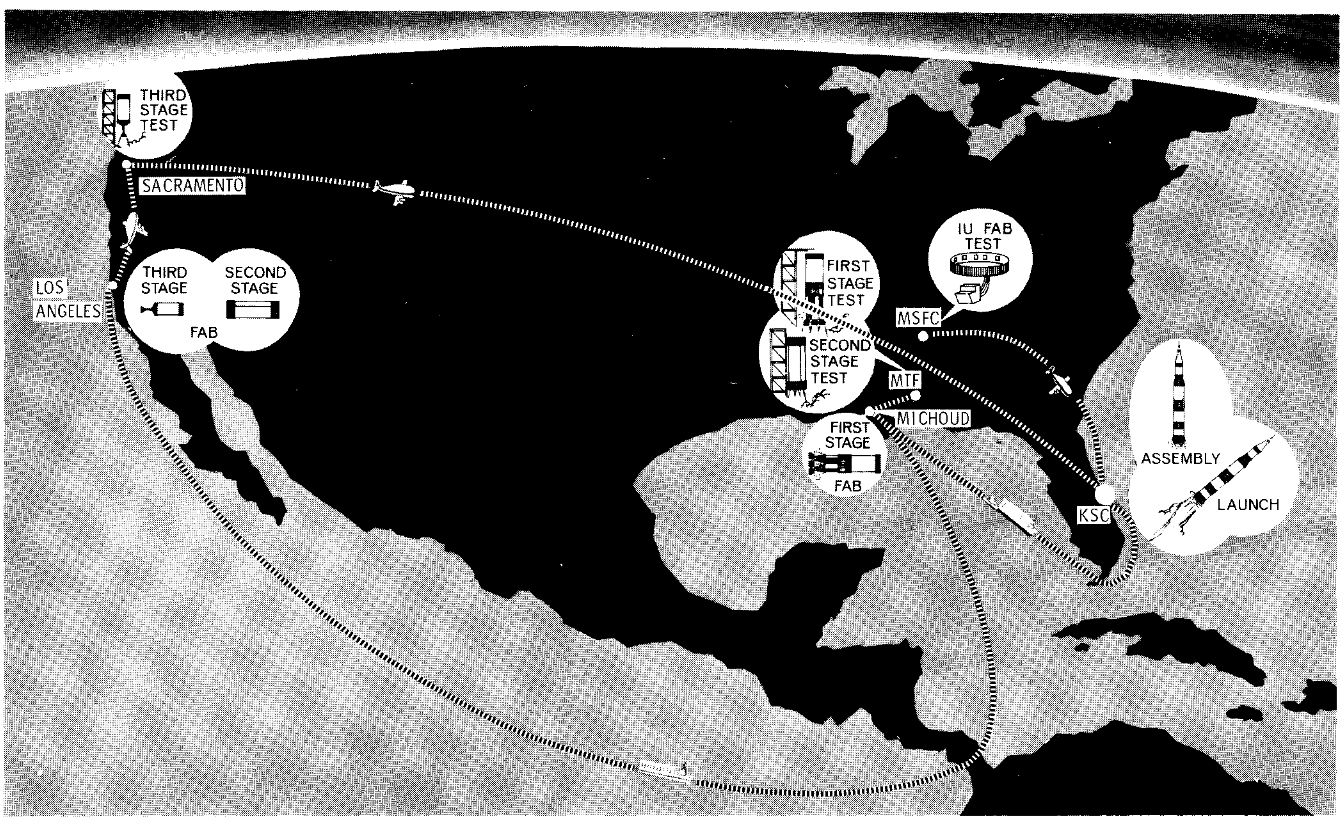
Every flight program is designed to provide a mass of vehicle performance information which is needed in planning future launches. Each stage carries a complete network of instrumentation to measure and record the performance of every system, subsystem, and vital component.

TEST DOCUMENTATION

In all Saturn V test operations, from ground development through flight, documentation of results is as important as the acquisition of data. The performance history of every part, component assembly, subsystem, and system must be accurately detailed and permanently recorded.

These records give engineers a basis for making evaluations of the performance of parts and subsystems. These evaluations provide maximum confidence in every vehicle.

The formidable task of record-keeping has necessitated the establishment of a test data bank for Saturn V program engineers. It can be an invaluable source of reference in the event of minor or major malfunctions in a test or flight.



Traveling Saturn– This depicts the Saturn V assembly and test sequence and the transportation routes of rocket-carrying craft.