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SATURN FIRST STAGE : WORKHORSE OF PRESENT - - FUTURE

CHRYSLER-BUILT SATURN BOOSTERS PROVIDE NASA WITH ALL-PURPOSE CAPABILITY FOR SPACE MISSIONS

Early in 1967, three astronauts will ride an uprated Saturn I vehicle into earth orbit in the first manned launch of the Apollo program. This flight will have been preceded by several unmanned flights. The first stage of these launch vehicles, the Saturn booster (S-IB), is manufactured by the Chrysler Corporation Space Division at the George C. Marshall Space Flight Center's Michoud Assembly Facility, New Orleans.

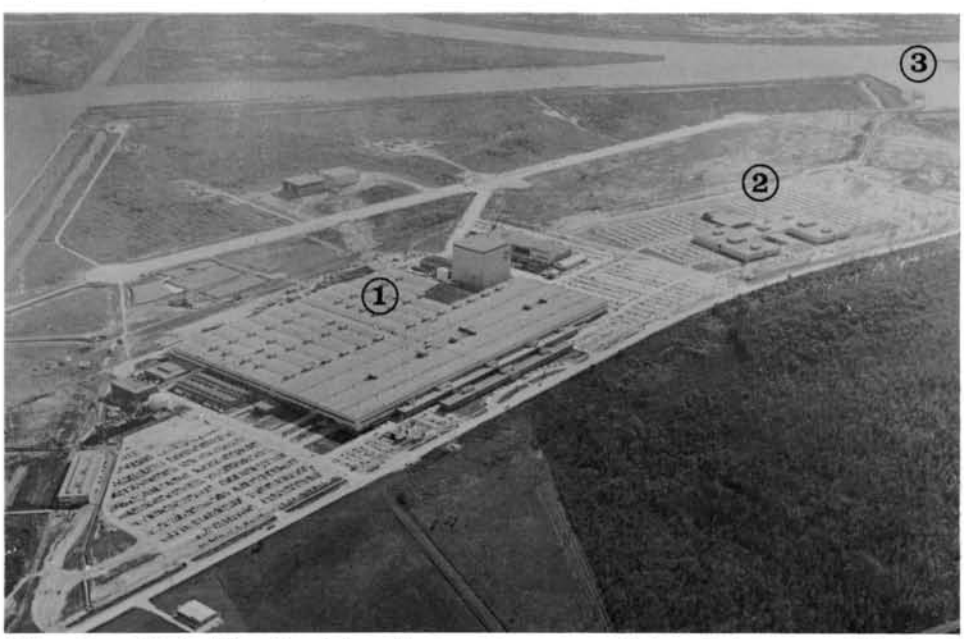
The eight engines of the booster generate 1,600,000 pounds of thrust and help place up to 40,000 pounds of payload into earth orbit. These powerful boosters, together with the Douglas-built second stages (S-IVB), may be used for a variety of missions. Uprated Saturn I launch vehicles are scheduled to be used in launching manned and unmanned Apollo spacecraft and Lunar Modules into earth orbit for their critical tests in space.

In the meantime, the Chrysler Corporation Space Division is studying possible advanced missions for the uprated Saturn I and methods to further increase the versatile launch vehicle's capabilities for future space work.

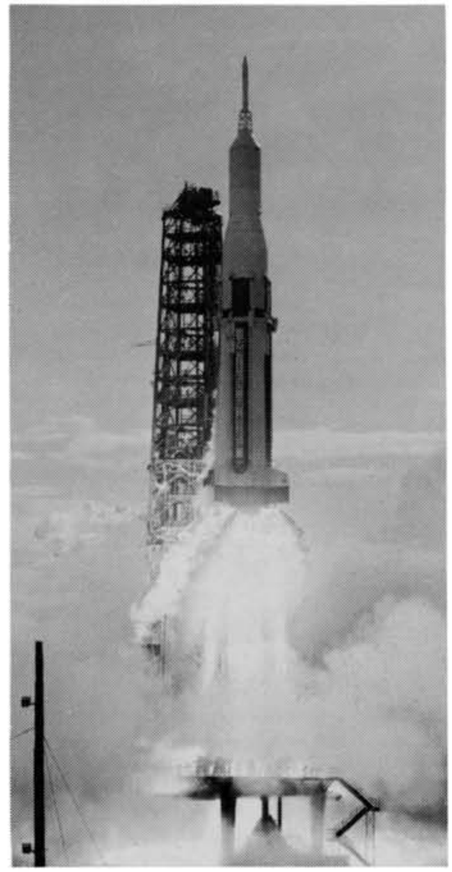
The first stage of the uprated Saturn is an outgrowth of the highly successful Saturn S-I booster developed by a group of NASA scientists and engineers headed by Dr. Wernher von Braun, who is director of all Marshall Space Flight Center (MSFC) installations with headquarters in Huntsville, Alabama.

It was the Saturn I whose first flight on October 27, 1961, proved feasible the concept of clustered propellant tanks and interconnected engines that would permit mission fulfillment even if one engine did not perform properly. The first Saturn was followed by seven more flight stages built by MSFC in Huntsville. In December 1961, the Chrysler Corporation received the contract to build Saturn S-I boosters.

In 1963 Chrysler's contract was modified to include the design and manufacture of 12 first stage boosters for the uprated Saturn I. Chrysler's task included redesigning the stage for more powerful engines and, at the same time, reducing stage weight by 15 per cent. Actually, a more than 20 per cent reduction was achieved.



Michoud Assembly Facility. From left to right the major areas are: 1) the main factory area, 2) Engineering Building, and 3) the Michoud Dock on the Mississippi River Gulf Outlet.

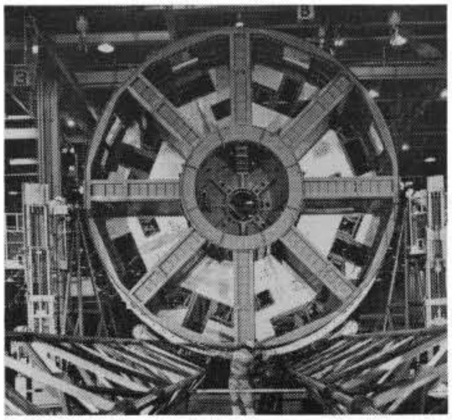


SA-10 roars off launcher in successful flight July 30, 1965.

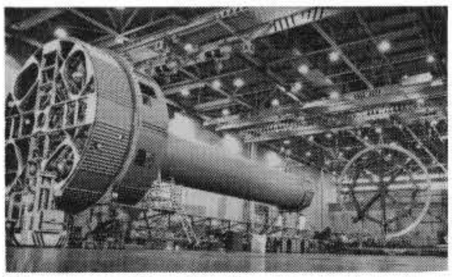
The government-owned Michoud plant in New Orleans was selected by NASA in September 1961 for the manufacture of the stages. Designed originally as a shipyard, the plant was used briefly for the manufacture of cargo planes and later, during the Korean conflict, for the manufacture of Chrysler-built tank engines. The plant remained idle from July 1953 until its selection by NASA. Part of Chrysler's contract with NASA was to renovate a portion of the plant and prepare it for the manufacture of the Saturn S-I boosters. Assembly of the first Chrysler-built booster began in October 1962.

A major milestone was achieved in NASA's Saturn/Apollo program on July 5, 1966, when SA-203 was successfully launched from Cape Kennedy. It was the second launch of the uprated Saturn I and the fourth launch of Chrysler-built Saturn boosters.

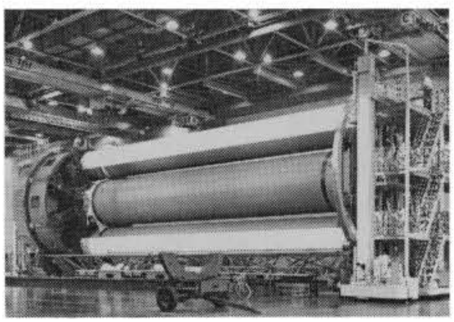
This was the first flight of an uprated Saturn I incorporating the total structural redesign performed by Chrysler. This redesign resulted in a weight savings of 10 tons over earlier Saturn boosters and made possible the largest U.S. payload (29 tons) ever lofted into orbit.



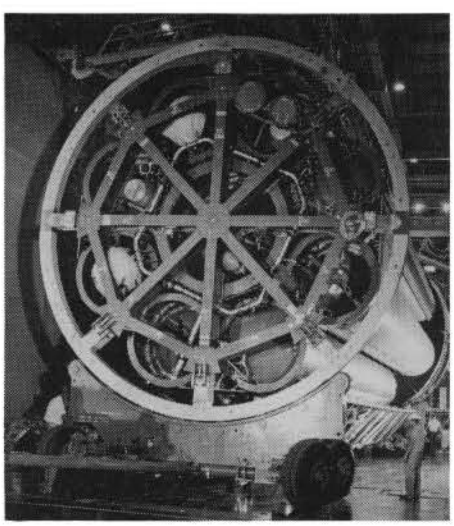
Tail unit, made up of the thrust support structure and tail shroud, rests on the final assembly fixture in preparation for clustering.



The center 105-inch liquid oxygen container has been mated to the tail unit and the spider beam is being brought into position for attachment to the container.



The second 70-inch liquid oxygen container is lowered into place during clustering. Two additional LOX and four fuel containers remain to be added.

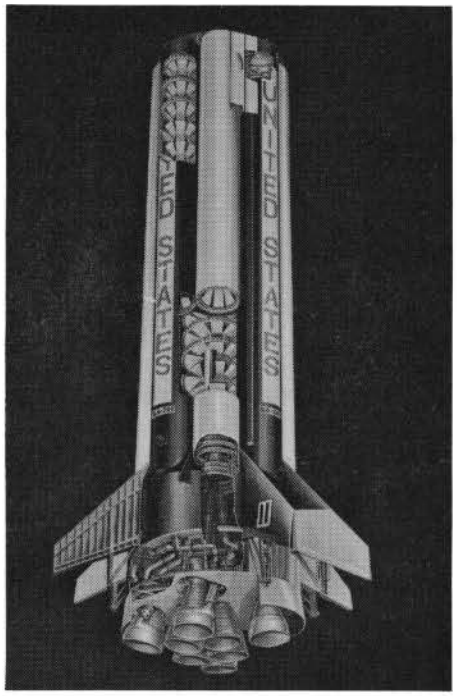


Following clustering of the propellant containers, a variety of hydraulic and pneumatic tanks and tubing as well as miles of electrical cabling are installed on the stages.

BOOSTER ASSEMBLY

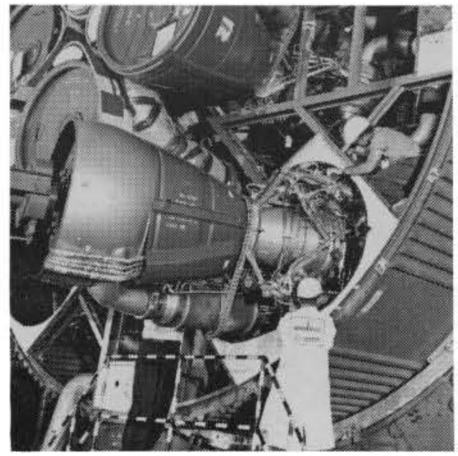
The 80-foot tall first stage weighs 84,000 pounds empty and about 1,006,000 pounds when fueled and ready for launch. More than 920,000 pounds of the load weight is liquid oxygen (LOX) and RP-1 propellant. The eight H-1 Rocketdyne engines consume propellant at the rate of over 700 gallons per second to develop the 1,600,000 pounds of thrust which launches the uprated Saturn I and its payload.

The basic structure of the first stage consists of a cluster of eight engines (four fixed inboard and four steerable outboard), a tail unit assembly, nine pro-



pellant containers, a spider beam unit assembly, and eight fin assemblies. To assemble the stage, a large cradle-shaped fixture is used. It is capable of rotating the entire stage even when it is fully assembled. First, the tail unit is placed in one end of the fixture and aligned. The large 105-inch diameter center LOX container is picked up from its transporter by an overhead crane, positioned, and attached to the center of the tail unit. Then the spider beam assembly is positioned in the opposite end of the fixture and attached to the LOX container. This is followed by the installation of the smaller 70-inch diameter LOX and fuel containers.

Each of these containers is lowered into place at the twelve o'clock position and fastened securely. Due to the balance requirements of the rotating fixture, the clustering of these smaller containers is performed in a sequence of opposite pairs. That is, after one container has been attached, the assembly fixture is rotated 180 degrees and the next container in-

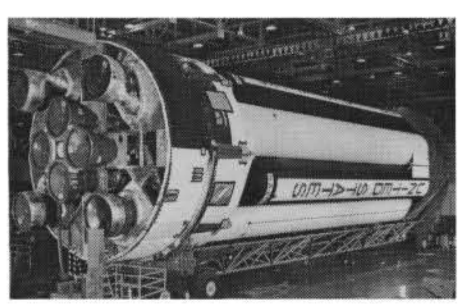


Technicians guide H-1 engine during its installation in first stage. The eight engines of this stage will generate over 1,600,000 pounds of thrust in flight.

stalled. At this time the assembly looks like a booster. Nevertheless, many weeks will still be required for the final installation of plumbing, wiring, electrical and hydraulic components, and engines.

For instance, more than 3,600 subcontractors and suppliers from 44 states provide a variety of parts from nuts and bolts to engines and propellant containers. The stage also requires 53 miles of wire, 1,700 electronic components, and 73,000 electrical connections. Each stage requires the use of about 44,000 feet of ordinary kitchen-type aluminum foil for wrapping tubing and other vital parts to protect them from dirt and contamination. And each stage requires 68 gallons of zinc chromate primer and other types of paint to protect the stage from corrosion and to provide a heat reflective coating for the liquid oxygen containers.

Because the stage is man-rated, quality control inspections are made of each part and each assembly operation to be sure that all components and structures will be able to stand the stresses of flight. When the stage has been completely assembled and all necessary inspections made, it is moved into functional checkout to verify that all systems can and will operate correctly.

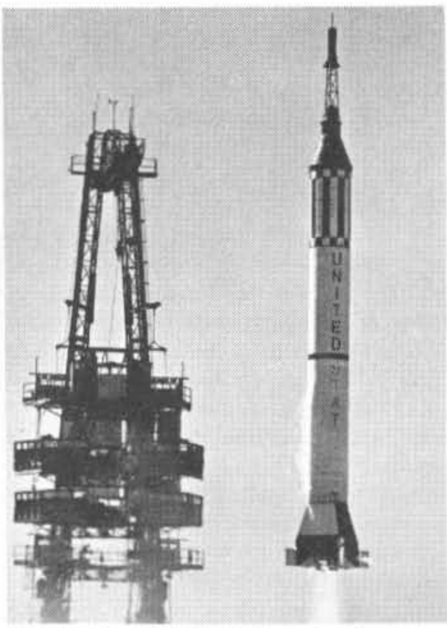


Fully assembled booster has been functionally checked out and prepared for shipment to MSFC for static firing. Covers (already on forward section) will be placed over entire stage for protection during shipment.

REDSTONE AND JUPITER PROGRAMS PROVIDED CCSD SPACE BACKGROUND

The history of the Saturn first stage booster reaches back to the Redstone missile, which was developed by a group of scientists headed by Dr. Wernher von Braun. The liquid fueled Redstone was 70 inches in diameter and 69.5 feet tall. Chrysler Corporation was awarded a contract to assist in the development of the Redstone in 1952. The Redstone had a 95 per cent reliability and, as modified to the Jupiter C and the Mercury-Redstone, was used to launch the first U.S. satellite and the first American astronauts.

The Redstone was followed by the Jupiter Intermediate Range Ballistic



Reliable Chrysler-built Redstone booster was used to send the first two American astronauts on sub-orbital flights.

Missile. The Jupiter vehicle was 105 inches in diameter and 60.3 feet tall. Like the Redstone, the Jupiter was modified and, as Juno II, was used to orbit a variety of U. S. satellites and to launch several deep space probes. The Chrysler-built Jupiter record of reliability was 100 per cent.

Saturn project studies had determined that the Jupiter engine and Redstone and Jupiter propellant containers could be modified and clustered for use on the proposed Saturn booster. In addition, certain of the tools and fixtures associated with these missiles could also be used.

Thus, it was possible to begin Saturn booster development with well-tested hardware of proven reliability, thereby shortening the time required for design, development, and manufacture and, at the same time, reducing all associated costs.

QUALITY CONTROL KEY TO SPACE VEHICLE RELIABILITY

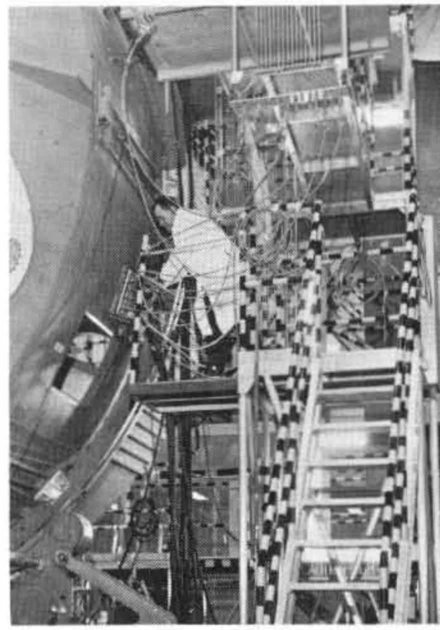
During the assembly of a first stage, quality control inspection operations are performed to verify that the various parts and assemblies are put together properly. To obtain assurance or confidence that all parts and systems will function correctly, a final quality control functional checkout is performed. This testing will essentially provide the following information.

It will tell that all of the electrical cables and harnesses are properly connected; that all parts, such as switches and valves, will open and close when the proper command is initiated; and that the containers and all the interconnecting tubing and lines are leak tight and will hold certain levels of pressure.

Functional checkout will also verify that the engines will move in the proper direction when commands from the on-board computer are given and that the telemetry packages transmit their information back to earthbound stations properly.

Telemetry on board the stage is similar to the radio and television transmitters which broadcast programs for home receivers. The telemetry packages monitor certain conditions which occur during flight and transmit this information back to control centers on earth for use in determining how the stage is functioning.

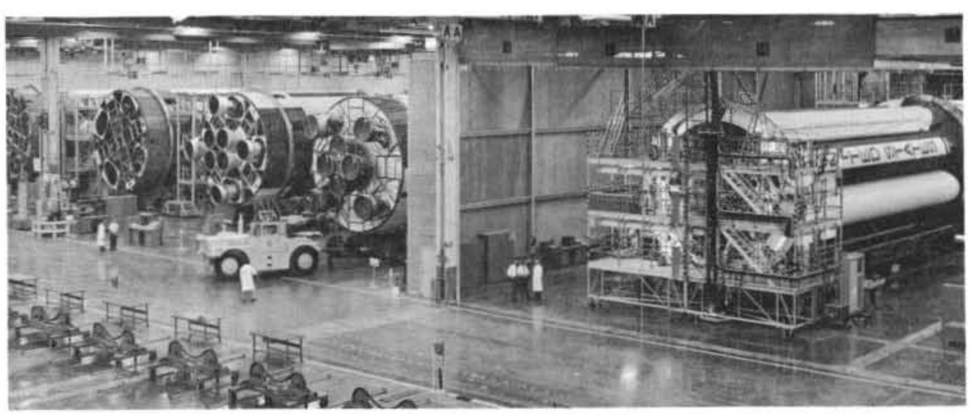
Even though there is no fuel in the tanks and the engines cannot be fired, many of the conditions of flight can be simulated by electronic and mechanical means. Test panels are designed and computer programs are prepared to simulate these functions and to allow an orderly sequence of events to occur when commands are given. A control room located behind the stage contains all of the test panels and control consoles through which the test is conducted. Closed circuit television cameras



In the functional checkout area, a technician connects a variety of hydraulic, pneumatic, and electrical lines to the stage. Pressures within many of the small pneumatic lines will reach to 3,000 psig during checkout.

placed around the stage enable the test conductor and others to monitor all events by means of monitors in the control room.

Commands and responses are passed between the stage and the control room through thousands of feet of electrical cabling and pneumatic tubing. There are approximately 1,000 cables which, if stretched end to end, would be approximately 12 miles long. There are approximately four miles of pneumatic pressure tubing which contain pressures from zero to 3,000 pounds per square inch. All of the tubing is cleaned internally to standards superior to those that prevail in hospital operating rooms. This allows clean air to be supplied to the stage without introducing contamination which would react and cause fire and explosion when liquid oxygen is loaded into the propellant tanks at the launch site. Man-rating of the stage requires that strict quality control standards be adhered to at all times during manufacture and testing.

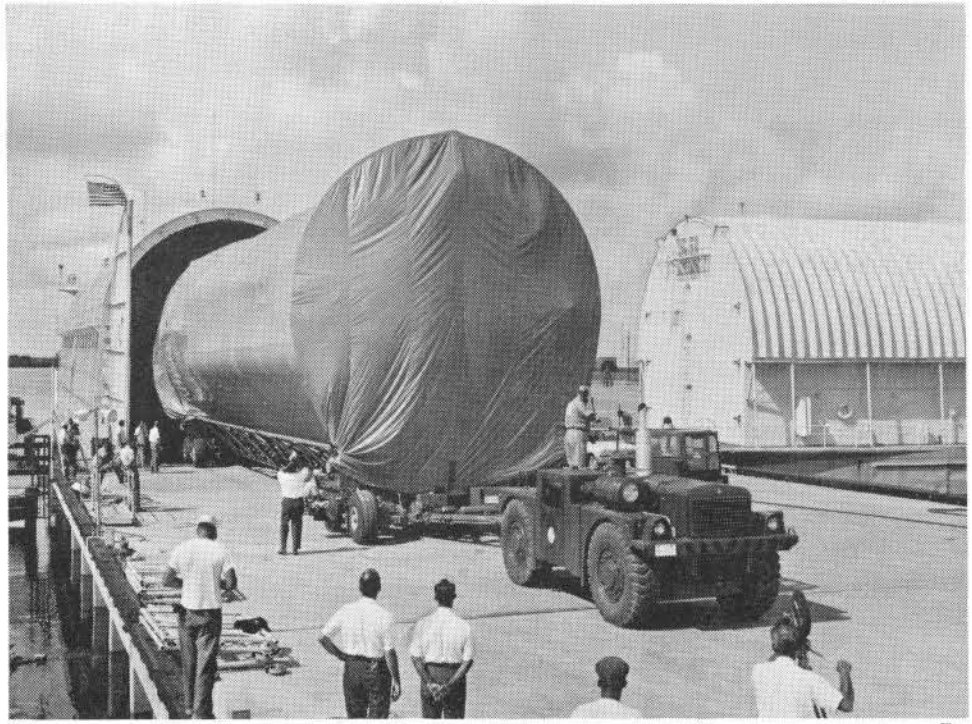


Five-stage lineup shows (left to right) two boosters in final assembly, two in modification, and one in functional checkout. Fixtures in the foreground are used to support the propellant containers during their final assembly.

SYSTEMS STATIC TEST BRANCH TEST FIRES SATURN S-IB BOOSTER

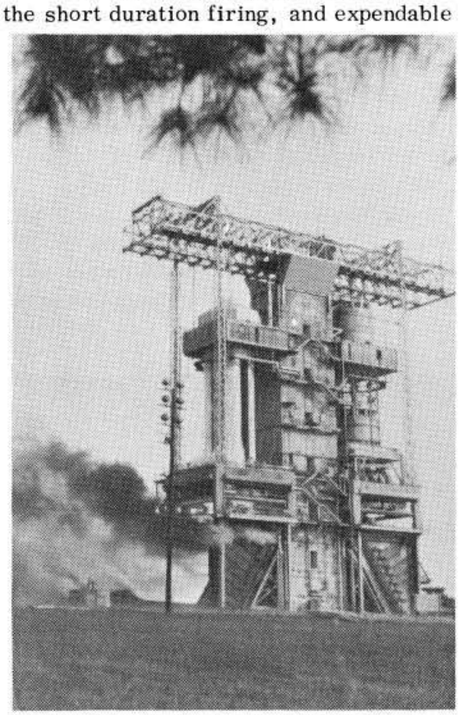
In terms of qualifying the first stage for launch, Chrysler's Systems Static Test Branch performs the most decisive acceptance test -- static firing of the stage. Even though each first stage is functionally tested following assembly, it is not qualified as launch-ready until it has been successfully test fired at NASA's George C. Marshall Space Flight Center in Huntsville, Alabama. Here, the stage is subjected to a short duration firing of approximately 35 seconds and a full, flight-length firing of approximately 140 seconds.

After arriving at the MSFC dock on the Tennessee River, the first stage is unloaded from the barge and towed to the test site. The stage is lifted from the transporter and hauled aloft into the test tower where it is aligned and secured. Electrical and mechanical connections are made and checked. The pneumatic, LOX, fuel, and hydraulic systems are then checked for leaks. Control systems are checked for proper operation and the instrumentation systems are calibrated. Then the stage is fueled and the short duration firing is conducted. The objectives of this test are to check the performance of the engines, the gimbal system, and the telemetry system; evaluate the modified fuel container system; determine the LOX boiloff rates; and evaluate propellant container transients with flight ullages.



Two NASA barges, the Palaemon (left) and the Promise, are used to transport stages to and from MSFC for static testing. Only the Promise, because of its greater size, is used to transport stages to Cape Kennedy.

The stage is inspected following the short duration firing, and expendable components are replaced to prepare the stage for the flight-length test. The objectives of this test are to demonstrate the performance of all flight systems and to generate data required to calculate the flight trajectory. After the full duration firing, the more than 1,000 recorded measurements are reviewed, evaluated, and reduced to graphs and charts for use in various reports and publications.



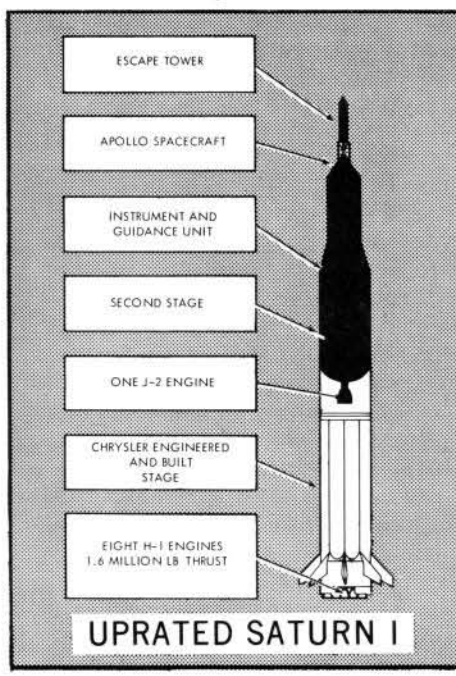
First stage undergoes static test firing at the Marshall Space Flight Center to gain assurance that all systems will perform correctly in actual flight.

The stage is then removed from the test tower, placed on the transporter, and shipped back to the Michoud Assembly Facility for the poststatic functional checkout.

By the time the first stage is ready for shipment to the NASA Kennedy Space Center, Florida, it has been modified to the flight configuration, been processed through functional checkout once again, and has had final flight hardware installed.

Following a five day trip to the Kennedy Space Center, the stage is unloaded from the barge and taken to the hangar. There, three of the eight fins are installed on the stage. The stage is then delivered to the launch complex where it is placed on the launcher. The remaining five fins are installed and the stage is made ready for the connection of all ground support equipment. These include the propellant lines, electrical and mechanical connections, and the pneumatic and hydraulic lines. Compatibility checks are then conducted between the stage, the launcher, and the control center. All of these checks are made by personnel of the CCSD Systems Launch Branch.

When the first stage has been completely checked out, the second stage is mated to it. That stage then goes through similar checkout activities. Later, checks are made to assure compatibility between the first and the second stage. These checks finished, the Instrumentation Unit, spacecraft, and Launch Escape System are mated to the Saturn launch vehicle in their turn. When the final checks of compatibility between all stages of the launch vehicle have been completed, the vehicle is ready for launch.



Shaded area in drawing shows upper stages of the uprated Saturn I vehicle and their relationship to the Chrysler-built first stage.