The American Society of Mechanical Engineers

ADVANCED ENGINE TEST FACILITY

George C. Marshall Space Flight Center
Huntsville, Alabama

National Historic Mechanical Engineering Landmark
Designated October 28, 1993

The “Space Race”

The world’s first artificial space satellite, the Soviet Union’s Sputnik I, was launched into space on October 4, 1957. While the United States entered the Space Age on January 31, 1958, with the launch of Explorer I, the Soviets continued to dominate this undeclared “space race” with larger rockets and payloads. Public pressure to get back on top in the space race led to President Eisenhower signing the bill that created the National Aeronautics and Space Administration (NASA) in July of 1958. NASA’s mandate was to develop the United States’ aeronautical and space exploration potential for the “benefit of all mankind.”

Launching an American astronaut into orbit was the goal of Project Mercury, which was announced in the fall of 1958. The United States was once again beaten to the punch by the Soviet Union when cosmonaut Yuri Gagarin became the first human to orbit the earth on April 12, 1961.

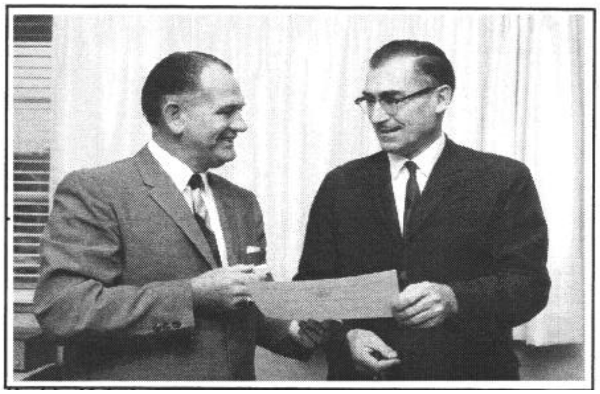
Realizing that prestige “was a real, and not simply a public relations factor in world affairs,” President Kennedy asked his Vice President, Lyndon Johnson, to study American options in space and determine which areas the United States could most likely beat the Soviets. In Johnson’s report on the subject, less than two weeks later, he strongly endorsed a plan to land an American on the moon. Kennedy’s initial reservations were quickly erased by the enthusiastic response to Alan Shepard’s Mercury *Freedom 7* flight on May 5, 1961, and he became convinced that the time was right for such a commitment. In the years to follow, one of the most highly technical peace-time programs ever in the United States was undertaken. The combined efforts of government, industry, and academia peaked at over 350,000 people and over 20,000 companies throughout the country. This was Project Apollo.

The heart of the project was the Saturn V launch vehicle that launched the Apollo spacecraft on its journey to the moon. The Saturn V was the most powerful rocket ever built. A crucial element of the development and reliability establishment of the Saturn V was vehicle stage testing. For this, a massive new facility was required.

The S-IC Stage Static Facility at NASA’s George C. Marshall Space Flight Center (MSFC) in Huntsville, Alabama, was designed and built to test the first stage, the S-IC stage, of the Saturn V launch vehicle. The stand contains 12 million pounds (5.44×10^6 kg) of concrete in its base legs and could accept an engine configuration generating thrusts to that level. In the Saturn IC stage, each of the five F-l engines developed 1.5 million pounds (6.67×10^6 N) of thrust for a total lift-off thrust of 7.5 million pounds (33.36×10^6 N). Between April 1965 and August 1966, eighteen tests were completed on the S-IC-T (built for test only) stage of the Saturn V launch vehicle, and during 1966, testing was completed on the first three S-IC flight stages. The Saturn V test program was completed in August of 1967. The success of this test program was a vital step toward achieving a lunar landing within that decade.

On July 20, 1969, the Apollo 11 lunar module *Eagle* landed on the moon’s Sea of Tranquility and the crew was returned safely to earth on July 24, 1969, thereby meeting President Kennedy’s 1961 goal.

Design and Construction



Karl L. Heimburg and B.R. Tessmann have worked together since 1942. Picture taken in mid- 1960s.

Dr. Wernher von Braun, the first Director of the National Aeronautics and Space Administration's Marshall Space Flight Center, was responsible for conceiving, designing, and constructing the SI-C Stage Static Test Stand. The design and construction was carried out by the Center's Test Laboratory under the direction of the Test Laboratory Director, Karl L. Heimburg and his Deputy, B.R. Tessmann.

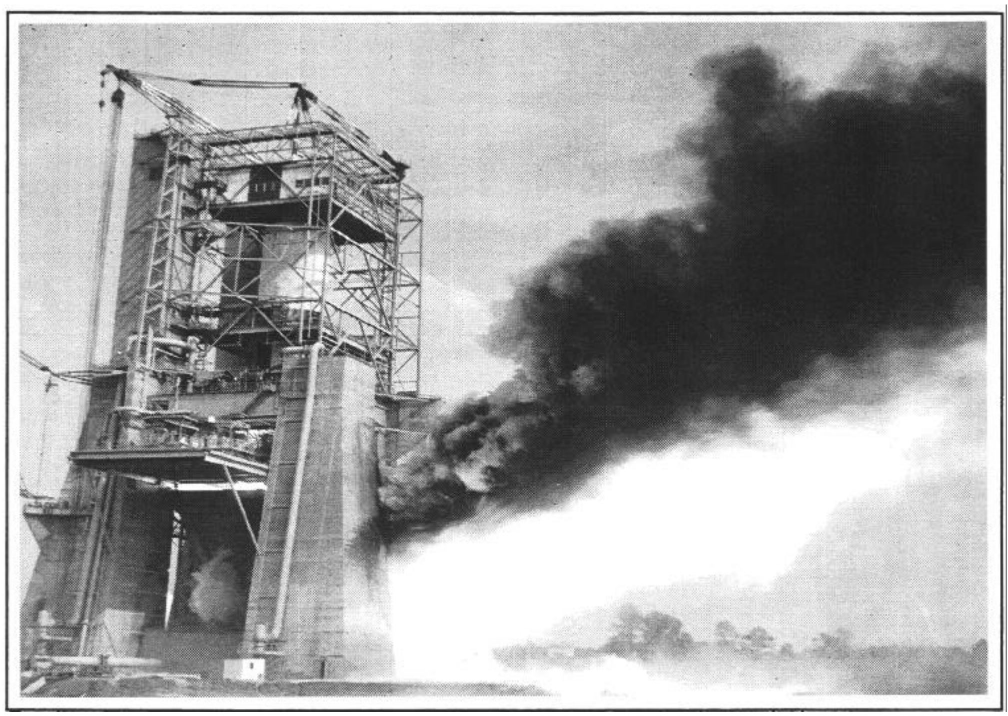
Brown Engineering Co. of Huntsville, Alabama, (now Teledyne Brown Engineering) provided engineering and design support to NASA for the SI-C Stage Static Test Stand. The Mobile District, U.S. Army Corps of Engineers supervised construction. Ets, Hokin, and Galvan, Inc., of San Francisco, California, held the major construction contract for building the main structural portion of the test stand. The contract for fabrication of the SI-C Stage Static Test Stand superstructure was awarded on August 31, 1962. Numerous subcontractors were also employed, including Algernon-Blair Construction, Inc., of Montgomery, Alabama.

Late in July 1963, the concrete towers for the S-IC Static Test Stand were completed and steel erection was begun. Construction progressed on the $30 million static test facility during March of 1964. This Saturn V static test facility was to be used to test four S-IC stages including one flight booster built by Boeing, a non-flight MSFC-built stage, and the first two S-IC flight stages, both to be built by MSFC. A dozen or more S-IC-T stages were also to be tested.

Testing

On March 1, 1965, MSFC lifted the first Saturn V booster ground test stage into the test stand. This stage, SIC-T, would be used in a series of hot firings to test operation of the engines, related systems, and firing equipment. Testing and checkout of this MSFC-assembled stage proceeded throughout the month of March.

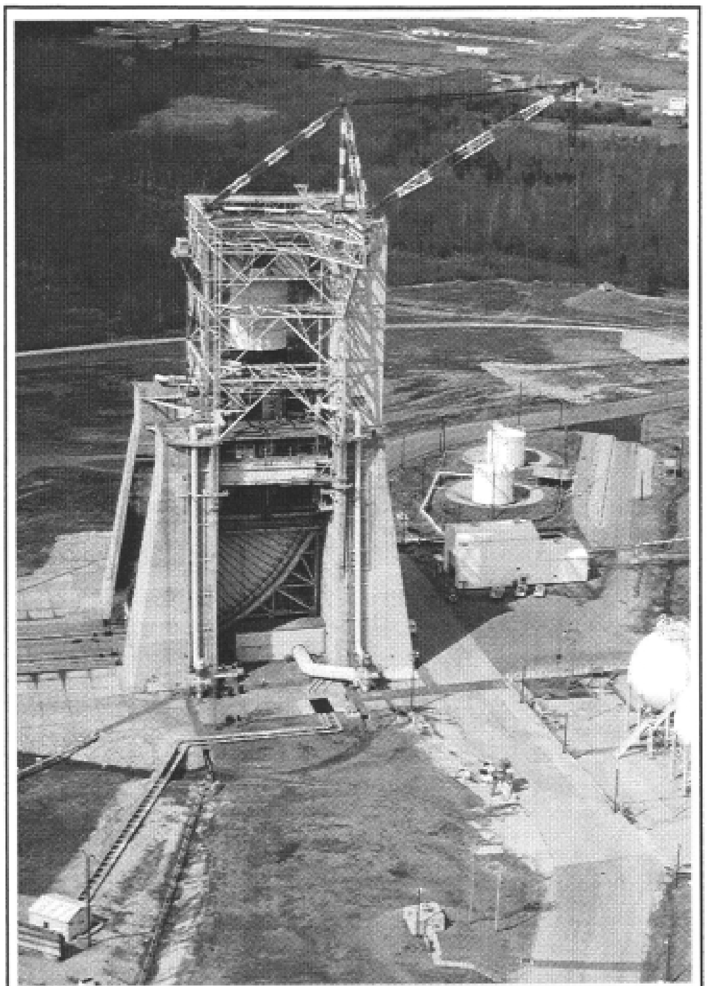
A significant milestone in Saturn V development was reached during April with the



The first full duration static test firing of all five F-l engines on the Saturn S-IC stage.

first ground firings of this S-IC-T stage. On April 10, 1965, MSFC successfully conducted a 16.73-second, single-engine firing of this stage. On April 16 MSFC successtully tired all five of the stage's powerful 18.5-foot-high (5.64 m) engines for 6.5 seconds, generating 7.5 million pounds ($33.36x10^6$ N) of thrust (see picture on previous page). More than 500 measurements of the booster's performance were made during this test firing. At 4 p.m. on August 5, 1965, the giant non-flight replica booster came to life again for the first 2-1/2 minute, full-duration firing of the S-IC-T stage.

By mid-December 1965, fifteen S-IC-T static firings, totaling 867 seconds, were completed at MSFC. Three were full-duration firings. Early in 1966, however, MSFC conducted static tests on actual S-IC stages built to fly. The first of these tests was performed on February 17, 1966, and lasted 40 seconds. The second, and final, static test of the flight booster was conducted on February 25, 1966. During both of these tests, the S-IC stage's five Rocketdyne F-1 engines burned 15 tons (13608 kg) of liquid oxygen and kerosene each second to produce 7.5 million pounds ($33.36x10^6$ N) of thrust, 1.5 million pounds ($6.67x10^6$ N) of thrust per engine. The Saturn V test program was completed in August 1967 and the booster was certified to fly.



Aerial view of the S-IC Static Test Stand looking north.

Specifications & Features

The S-IC Stage Static Test Stand, now called the Advanced Engine Test Facility, is located at NASA's George C. Marshall Space Flight Center in Huntsville, Alabama. The test stand was used to test the largest rocket unit ever developed in the United States space program. The Saturn V first stage was 33 feet (10.06 m) in diameter, 138 feet (42.06 m) long, and generated a total of 7.5 million pounds ($33.36x10^6$ N) of thrust from its five F-l engines. However, the foundations for the stand were designed with the capability to test even larger boosters, producing up to 12 million pounds ($53.38x10^6$ N) of thrust, should the need arise.

Foundations for the test stand are set in the bedrock some 40 feet (12.2 m) below the ground. The stand has four 144-foot-high (43.9 m) hollow concrete legs (with walls 4 feet (1.2 m) thick) that are 47 feet square ($4.37 m^2$) at the base and 30 feet square ($2.79 m^2$) at the top. Shop and instrumentation rooms are located in the legs. The steel superstructure extends 122 feet (37.2 m) above the concrete portions to the 266-foot (81.1 m) level, and a 135-foot-long (41.1 m) boom of a 200-ton ($181.4x10^3$ kg) crane atop the superstructure makes the stand reach more than 400 feet (121.9 m) into the sky.

One of the larger features of the stand is its 1,900-ton (1.72x10^6 kg) flame deflector (as seen in the picture on the previous page), the large steel flame deflector was constructed outside the stand and moved on wheels to its position beneath the thrust load platform. Some 273,000 gallons (1.03x10^6 L) of water was forced through the deflector's more than 387,000 holes each minute during S-IC tests. The flame deflector, or "flame bucket" as test personnel call it, is constructed of one-inch-thick (2.54 cm) steel plate. The holes through which the water flows are 5/32-inch (0.4 cm) in diameter. The pattern of these holes is not uniform over the surface of the deflector, but is designed to optimize the flow and heat rejection requirements.

Cooling water is pumped about 10 miles (16.09 km) from the Tennessee River through pipes that are 12 inches (30 cm) in diameter to two storage tanks outside the pump house. Water from these two 3.5 million gallon (13.25x 10^6 L) tanks flows into each pump through 36-inch (0.91 m) diameter pipes and leaves the pump house through one 96-inch (2.44 m) diameter pipe to the test stand area. Thirteen American Locomotive Company (ALCO) diesel engines each generate 2577 hp (1922 kW) and turn 13 DeLaval pumps at 800-900 rpm. At full load, each can pump 21,000 gallons per minute (79.49x10^3 L/min). At maximum, the flow rate through this 96-inch (2.44 m) pipe is 273,000 gallons per minute (1.03x10^6 L/min). During a test, this water also supplies the fire suppression system. At the S-IC stand, the 96-inch (2.44 m) diameter pipe divides into four 42-inch (1.07 m) diameter pipes that run up each of the four concrete legs of the stand and supply water to the flame deflector and fire suppression systems.

- THRUST CAPABILITY
  - 7.5 million pounds (33.36x10^6 N)
  - Foundation designed for 12 million pounds (53.38x10^6 N)
- CRYOGENICS
  - Liquid Hydrogen
    - 450,000 gal off stand' (1.7x10^6 L)
    - 75,000 gal on stand (283.9x10^3 L)
  - Liquid Oxygen
    - 23,000 gal on stand (87.1x10^3 L)
- GASES
  - hydrogen (GH_2)/nitrogen (GN_2)/helium (GHe)/air
- FUEL
  - 150,000 gal of Rocket Propellant-l (RP-1) (567.8x10^3 L) (shared with the F-l engine test stand)
- DEFLECTOR COOLING WATER
  - 273,000 gal/min @ 185 psig (1.03x10^6 L/min @ 1.28x10^6 Pa)
- INSTRUMENTATION
  - 750 channels digital
  - 108 channels analog

Current Technical Specifications

Present Day

Modifications to the test stand began in 1974, to accommodate liquid hydrogen (LH_2) for Space Shuttle External Tank structural verification testing. Gaseous hydrogen (GH2) at a pressure of 3100 psig (21.37x10^6 Pa) is used to force LH_2 from off-stand through vacuum-jacketed piping to the retaining tank on-stand. No LH_2 is transferred during testing and all lines are purged of GH_2. These tests were completed in 1980.

The Facility was again modified in 1986 to accommodate the Technology Test Bed engine which is a derivative of the Space Shuttle Main Engine (SSME). Its name was changed at this time to the Advanced Engine Test Facility. Upon a successful checkout of the facility, the SSME Engine Technology Test Program was begun. This program continues.

The stand is presently used for the on-going Technology Test Bed Program at the Marshall Center. However, when testing is not in progress, thousands of visitors see it each year as part of the NASA bus tour conducted by the Space and Rocket Center in Huntsville, Alabama.

In 1974, the S-IC Static Test Stand was modified to accommodate liquid hydrogen capability for the Space Shuttle External Tank structural verification testing.

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ASME History and Heritage Program

The ASME History and Heritage Recognition Program began in September 1971. To implement and achieve its goals, ASME formed a History and Heritage Committee, initially composed of mechanical engineers, historians of technology, and (ex-officio) the curator of mechanical engineering at the Smithsonian Institution. The committee provides a public service by examining, noting, recording, and acknowledging mechanical engineering achievements of particular significance.

The Advanced Engine Test Facility is the 107th National Historic Mechanical Engineering Landmark to be designated. Since the ASME History and Heritage Program began in 1971, 157 Historic Mechanical Engineering Landmarks, 6 Mechanical Engineering Heritage Sites, and 4 Mechanical Engineering Collections have been recognized. Each reflects its influence on society in its immediate locale, nationwide, or throughout the world.

An ASME Landmark represents a progressive step in the evolution of mechanical engineering. Site designations note an event or development of clear historical importance to mechanical engineers. Collections mark the contributions of a number of objects with special significance to the historical development of mechanical engineering.

The ASME History and Heritage Program illuminates our technological heritage and serves to encourage the preservation of the physical remains of historically important works. It provides an annotated roster for engineering students, educators, historians, and travelers. It helps establish persistent reminders of where we have been and where we are going along the divergent paths of discovery.

The History and Heritage Committee is part of the ASME Council on Public Affairs and the Board of Public Information. For further information, please contact the Public Information Department, American Society of Mechanical Engineers, 345 East 47th Street, New York, NY 10017, (212) 705-7740.

NATIONAL HISTORIC MECHANICAL ENGINEERING LANDMARK

George C. Marshall Space Flight Center Advanced Engine Test Stand
1964

This facility was built for static tests of the Saturn V rocket booster first stage and other large boosters producing up to 12 million pounds of thrust. It was conceived by Wernher von Braun, and Karl L. Heimburg led the design team. More than 850 engine parameters can be monitored, including thrust, fuel and oxidizer flows, temperatures, and pressures. A moveable platform provides access to the engines for test preparation. To facilitate the loading of test objects, the flame deflector can move away from the stand on a track. During a test, 273,000 gallons of water a minute can be pumped through holes in the deflector to control deflector temperature and vibration.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
1993

ASME Plaque

Acknowledgments

The North Alabama Section of the American Society of Mechanical Engineers gratefully acknowledges the efforts of all who contributed to the designation of the Advanced Engine Test Facility as a National Historic Mechanical Engineering Landmark. Particular thanks are extended to Mike Wright, MSFC Historian, and Sandra Turner, Chief of Protocol at MSFC, for their encouragement, guidance, and suggestions in organizing this event.

The North Alabama Section would also like to thank the following companies for their generous support in orgainzing this event:

- Alabama Space & Rocket Center
- Barge, Waggoner, Sumner and Cannon Engineers-Architects-Planners
- Boeing Defense & Space Group
- CV Associates, Inc.
- McDonnell Douglas Aeorspace
- Reisz Engineering
- Sverdrup Technology, Inc.
- Teledyne Brown Engineering

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