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Saturn's Growing Pains

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Introduction

The beginning of the Space Age was ushered in by a series of Soviet space spectaculars which clearly demonstrated that the Soviet Union had an immense lead in rocket technology. One of the more compelling measures of this lead was payload capability: Typical Soviet spacecraft were over an order of magnitude heavier than their miniaturized American counterparts. But even before the end of the first year of the Space Age, a group of engineers at the Army Ballistic Missile Agency (ABMA) lead by German rocket expert Wernher von Braun were already developing a heavy-lift launch vehicle, initially called the Juno V, that would dwarf even the largest Soviet rocket (see **Juno V: The Prehistory of a Super Booster** in the September 1998 issue of *SpaceViews*). Eventually dubbed "Saturn", this evolving family of launch vehicles would be capable of orbiting payloads weighing tens of tons.

While the Department of Defense (DoD) and the Advanced Research Projects Agency (ARPA) initially embraced the von Braun team's Saturn concept with enthusiasm, by the close of 1958 fiscal realities combined with uncertainties about mission requirements were already threatening to derail Saturn's aggressive development schedule. By November of 1958 the plan called for the construction of five Saturn test vehicles: One for static tests and four for an initial flight test program to be completed by the last quarter of 1961. To keep this schedule, ABMA requested $60 million for Fiscal Year 1960 but this request was cut to $50 million by the Budget Bureau. A further blow was dealt to the infant Saturn program when on December 9, 1958 the DoD refused to grant the program a "DX" top priority rating. Such a rating, which would place the program first in line for required materials and talent, would have greatly facilitated the development of the new rocket.

Finding a Customer

Von Braun giving President Eisenhower a tour of Saturn facilities in Huntsville, Alabama. (MSFC/NASA)

To further complicate matters, there was the question of who Saturn's customers would be, whose requirements would drive development, and even who would ultimately control the ABMA, its facilities, and invaluable engineering talent. By the end of 1958, the USAF was well on its way towards monopolizing most aspects of military space activities. While the US Navy would find some specialized niches that allowed its own space program to survive, the US Army was slowly being pushed out of the picture all together. This was

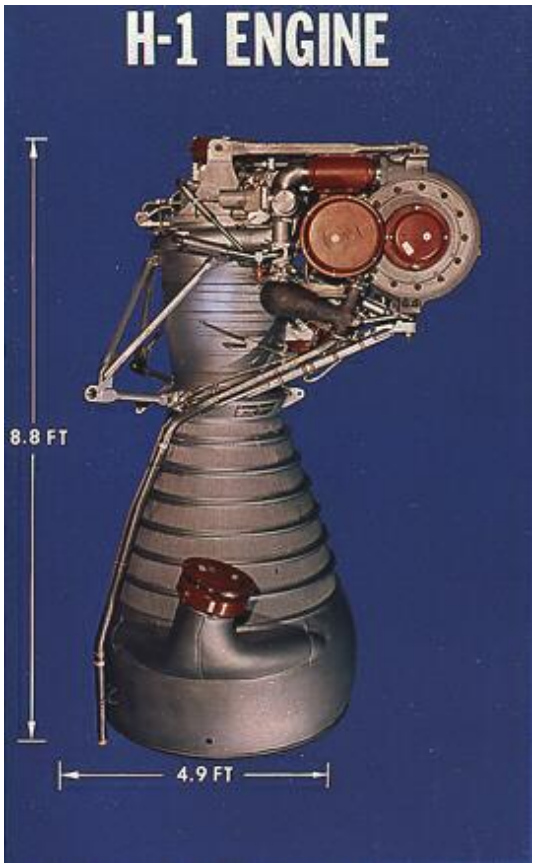
nothing more than a continuation of a trend that started in 1956 with a government policy decision that gave control of all long range missile development to the USAF with the US Army (and subsequently the ABMA) role being phased out.

Even as the Saturn program was beginning to ramp up in late 1958, the USAF had already written it off preferring instead to use a home-grown variant of their own Titan ICBM then under development. It was anticipated that this heavy-lift version of the Titan, designated "Titan-C", would be able to meet all of the DoD's future heavy lift requirements. This has indeed proven to be the case since the Titan-C studies lead to the development of the successful Titan III family of launch vehicles. The Titan III and its descendants (like the Titan 4B which still flies today) have been used to launch large DoD payloads for almost a third of a century.

While the USAF was not interested in developing Saturn, the DoD and the US Army were. The DoD supported the development of the Titan-C but felt that the Saturn design offered much more growth potential. The US Army also wanted the Saturn to support their series of proposed space initiatives including building a lunar colony as part of "Project Horizon". But as 1959 wore on it became increasingly clear that the Army would not be given the nod to undertake any mission that would require the lift capability of Saturn. With a long wish list of potential future missions that would require a heavy lift capability, NASA was probably Saturn's best potential customer.

But NASA also anticipated the need to develop launch vehicles even larger than the original Saturn. In addition, NASA management wanted such an ambitious and important hardware development effort to be done in house. Aware that ABMA would probably fade along with the Army's long range missile and space ambitions, in January 1959 NASA began to seek control of the ABMA including von Braun and his rocket team. NASA had already acquired the Jet Propulsion Laboratory and felt that ABMA with their Redstone facility in Huntsville, Alabama would be an invaluable addition to the fledgling agency. But throughout most of 1959 these overtures did not result in any sort of decision one way or another. So much ambiguity about the future of ABMA and Saturn only worsened the program's scheduling problems.

All these uncertainties had the greatest impact on determining the upper stage configuration of the Saturn. The first stage design with its cluster of eight H-1 engines was already settled. But for the Saturn test program to proceed beyond the initial four test flights, a decision would have to be made on the upper stages. One decision made was to use the advanced Centaur (being developed by the USAF) as the last stage of Saturn. While there were those who advocated using a modified ICBM (e.g. the Atlas or Titan) as Saturn's second stage, many felt that the development of high energy, hydrogen-fueled stages offered much more potential in the long run. The ultimate selection, however, would have to be based on the payload requirements of Saturn's customer and their development horizon. These were open questions at the beginning of 1959 with no official resolution readily at hand.



A cluster of eight H-1 engines was employed by the first stage of the Saturn. (NASA)

By February of 1958 there were three groups of Saturn configurations under consideration. The Saturn A would have a second stage consisting of either the first stage of the Titan or a new design using a cluster of four H-1 engines. The third stage of Saturn A would be the high-energy Centaur. The second configuration, Saturn B, would use a second stage with a cluster of four H-1 engines and a third stage with a cluster of four engines burning liquid

hydrogen and liquid oxygen generating 267 kilonewtons (60,000 pounds) of thrust. The fourth stage would again be the Centaur. The final configuration, called Saturn C, proposed using various configurations of the Centaur's advanced LR-115 engine in three upper stages.

The urgent need for selecting the upper stage configuration was stressed in a report submitted to ARPA on March 13, 1958. ARPA director Roy Johnson immediately set up a commission of men from NASA and DoD to study the issue. In May the committee recommended the Saturn A configuration to Johnson. But new program funding projections began to cast a troubling shadow. In addition to the funding shortfall in Fiscal Year 1960, the funding for Fiscal Year 1961 was scaled back from $250 million to $130 million. This would stretch out Saturn's initial four-flight test program to July of 1962. Along with the continued lack of definition for Saturn's mission, Johnson ordered a halt to upper stage design studies on July 29.

Hardware Development Proceeds

But while Saturn program managers wrestled with the question of the program's future, ABMA engineers and the program's contractors were making excellent progress with Saturn's enormous first stage. Development of the H-1 engine at North American Aviation's Rocketdyne division proceeded at a brisk pace. This was entirely due to experience with the direct ancestor of the H-1, the S-3D (used on the Jupiter IRBM), and its sister the MB-3 (employed by the Thor IRBM). The H-1 not only had to generate 10% more thrust than the S-3D, it would have to undergo some other serious modifications. With a cluster of eight of the older engines, a Saturn lift off would be like trying to simultaneously launch eight Jupiter IRBMs off the same pad. And the use of eight engines made it much more likely that one would fail in flight. As a result, the H-1 had to be easier to start and much more reliable than its predecessors.

By the time Rocketdyne got the contract to build the H-1 in September of 1958, their engineers already had a laundry list of improvements for the S3-D design under advance study. These were quickly incorporated into the new engine and by December 31, 1958 the H-1 completed its first full power test firing. By April of 1959, the H-1 started testing at the Redstone Arsenal. The H-1 would soon be ready for test firings in clusters.

When the last ABMA-built Jupiter IRBM rolled off the assembly line on July 27, 1959, engineers immediately started the modifications needed to build the cluster of Jupiter- and Redstone-based propellant tanks for the Saturn's first static test article the SA-T. The SA-T would be fitted with increasingly larger clusters of H-1 engines for static test firings at a facility in Huntsville. Starting with only a pair of engines, firings would proceed until the full compliment of eight engines were tested at full power.

The SA-T undergoing a static test firing. (NASA)

But as the development of Saturn hardware was making good progress, uncertainty about the program's future weighed heavily on everyone. With the realization that the Army would be consigned to playing a minor role in space General Bruce Medaris, who along with von Braun was instrumental in launching the first Explorer satellites (see **Project Orbiter: Prelude to America's First Satellite** in the January 1998 issue of *SpaceViews*) announced that he was resigning his leadership position at ABMA on October 18, 1959. Echoing the General's frustration, it was widely known that von Braun was less than pleased with the situation and would quit if Saturn was cancelled. But within days there finally seemed to be some movement towards resolving a number of questions surrounding the Saturn program. On October 21, 1959 President Eisenhower approved the NASA plan to assume control of parts of the ABMA. While the decision would require Congressional approval, the plan called for a transfer of 5,000 workers from ABMA's Development Operations Division which included the von Braun team.

Decisions Made

With this decision, the Saturn program quickly came into focus. On December 15, 1959 the Saturn Vehicle Committee made the final recommendation for the Saturn upper stage configuration: The Saturn C-1. This configuration, which would be capable of sending over four tons to the Moon, had much more potential than the Saturn A and could meet NASA's anticipated heavy lift requirements. The first stage, designated S-I, was already under development. The second stage, called S-IV, would use four new engines burning liquid hydrogen and liquid oxygen to produce 356 kilonewtons (80,000 pounds) of thrust. The final stage would be based on the USAF Centaur. There were also plans for a much larger second stage designated S-II. It would use the same high energy propellants as the S-IV but be equipped with four larger J-2 engines. Developed by Rocketdyne, the J-2 would provide the S-II with a total of 3,560 kilonewtons (800,000 pounds) of thrust which would vastly improve Saturn's payload capabilities. At the beginning of February 1960, Rocketdyne got the contract to build the J-2 and prospective bidders were briefed on the S-II. Around the same time, the Saturn program finally got the "DX" rating it needed to keep to its development schedule. The future of the Saturn program finally seemed bright.

On March 28, 1960 live firings of clusters of H-1 engines on SA-T test article started. By April 29 the full compliment of eight engines was fired at full power for eight seconds. Over the coming weeks, the burn time was gradually increased to 121 seconds. In the mean time, assembly of the first Saturn flight article, SA-1, had started by the end of May. And after years of uncertainty, von Braun's team was officially transferred to NASA along with their facilities in Huntsville and at the Eastern Test Range on Cape Canaveral, Florida. On July 1, 1960 the new NASA facility officially became the George C. Marshall Space Flight Center. While the Saturn program was finally under way and its future secure, it was still only the first step in a decade-long journey which culminated in the first manned lunar landings.

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