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Juno V: The Early History of a Super Booster

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Introduction

The launching of the first Sputnik satellites in 1957 and 1958, which weighed as much as 1.3 metric tons (2,900 pounds), clearly demonstrated that the Soviet Union had a lead over the West in rocket technology. Within a couple of years, Soviet design bureaus started flying improved rockets that could launch more than 4.5 metric tons (10,000 pounds) into orbit. The fact that contemporary American rockets could loft only a small fraction of this mass was a major concern not only to engineers and scientist in the West that hoped to conquer the space frontier but to the political leaders that watched American technological preeminence fade with each Soviet space achievement.

Despite the early lead in lift capability the Soviet Union enjoyed, by the beginning of the Space Age American rocket engineers already had plans in motion for large boosters that would dwarf current Soviet launch vehicles. During the late 1940s and 1950s the Rocketdyne Division of North American Aviation, Inc. had been developing large rocket engines for use in America's first generation of long range missiles. Anticipating the need for still larger engines in the future, Rocketdyne started feasibility studies on one million pound thrust-class (4,500 kilonewton-class) engines in March of 1953. This was an order of magnitude larger than anything built to date. After two years of work, Rocketdyne had established that building such an enormous engine was possible.

Despite USAF leaders' public stance on launching scientific satellites into orbit as part of the International Geophysical Year (i.e. they could not be bothered), they were secretly pursuing the possibility of launching military payloads into orbit. The USAF knew that large engines like that studied by Rocketdyne would eventually be required to meet their heavy lift needs. Realizing this, the USAF funded Rocketdyne for additional work as part of the Air Force Rocket Engine Advancement Program which eventually lead to the development of the 6,700 kilonewton (1.5 million pound) thrust F-1 engine.

German rocket specialist Wernher von Braun who lead the Saturn development program. (MSFC/NASA)

By 1957 the DoD (Department of Defense) began to consider a variety of advanced space missions with military applications including communication and weather satellites. As envisioned at the time such payloads required a rocket that could lift 9 to 18 metric tons (20,000 to 40,000 pounds) into low Earth orbit. Such a rocket would be far larger than anything that was being built and would require the million-pound thrust (4,500 kilonewton) engines then being developed under USAF sponsorship.

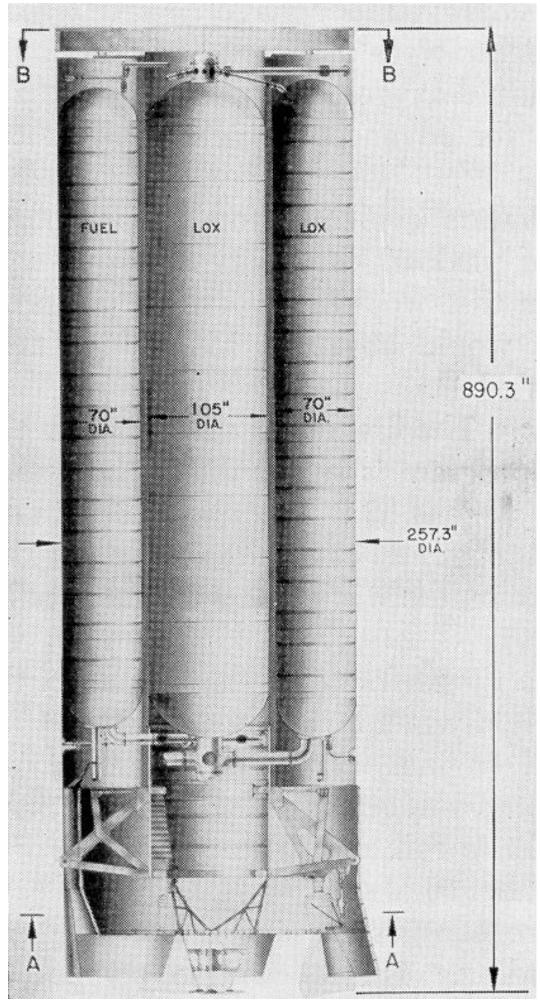
Enter the Juno V

Anticipating the need for such a large booster not only to send heavy payloads into orbit but also to quickly transport troops and equipment over intercontinental distances, an ABMA (Army Ballistic Missile Agency) team lead by Wernher von Braun started development work on super booster concepts in 1956 as part of follow on studies for Project Orbiter. While a single F-1-class engine would be ideal for such a rocket, this engine would not be available for years. Instead the ABMA team decided to cluster smaller engines to get the liftoff thrust they needed. Starting in April of 1957, von Braun and his team started putting considerable effort into the development of a heavy lift rocket that was initially called the Juno V.

The original design proposal for the Juno V concentrated on the development of the first stage of the rocket. To get the required lift off thrust they decided to use a cluster of Rocketdyne E-1 engines. The E-1 engine, with a thrust of 1,600 kilonewtons (360,000 pounds), was originally built by Rocketdyne in 1956 as a research tool to bridge the gap between the 150,000 pound thrust-class (670 kilonewton-class) engines they were developing for the Jupiter, Thor, and Atlas missiles and the enormous F-1 engine. A cluster of four E-1 engines would give the Juno V a liftoff thrust of 6,400 kilonewtons (1.4 million pounds).

In order to save further on development time and construction costs, the ABMA team extended the cluster concept further. If the Juno V used a conventional design, it would require enormous propellant tanks with a diameter of about 5.7 meters (19 feet). Designing, building, and qualifying such a large structure from scratch would take several years and require the mastery of new manufacturing procedures. Instead the ABMA team proposed that eight 70-inch (1.78 meter) in diameter tanks be clustered around a central 105-inch (2.67 meter) tank in a structure with a total diameter of 6.4 meters (21 feet) and a length of 22.6 meters (74.2 feet). The 70-inch tanks would use the tooling and manufacturing procedures already in place to build the propellant tanks for ABMA's Redstone missile which had an identical diameter and structure. Likewise the 105-inch tanks would be based on the ABMA-developed Jupiter IRBM propellant tanks. Other systems the rocket required would also use off-the-shelf-hardware adapted from ABMA missiles.

This cluster of tanks would carry 340 metric tons (750,000 pounds) of propellant for the cluster of E-1 engines mounted in a tail section structure that held the bottom of the tanks. The central 105-inch tank and four of the 70-inch tanks would hold LOX (liquid oxygen) while the other four 70-inch tanks would hold RP-1 kerosene. A spider-beam assembly at the top of the stage would hold the tops of the tanks and provide support for the upper stages. This innovative design was certainly not optimum but it provided an easy to develop, brute force solution to the heavy lift problem.



Drawing showing the clustered tank structure of the Juno V (better known as the Saturn I). (NASA)

Development Moves Forward

Like many other space-related programs, the development of Juno V would have remained in low gear indefinitely were it not for the major shock caused by the launching of Sputnik 1 on October 4, 1957. In the midst of meetings about an American response to Sputnik among ABMA engineers at Fort Bliss, the Juno V was discussed at length on October 20, 1957. The development program began to move forward and lead to the submission of a report titled "A National Integrated Missile and Space Vehicle Development Program" on December 10, 1957. This report detailed the attractiveness of the Juno V concept and called for its development starting in

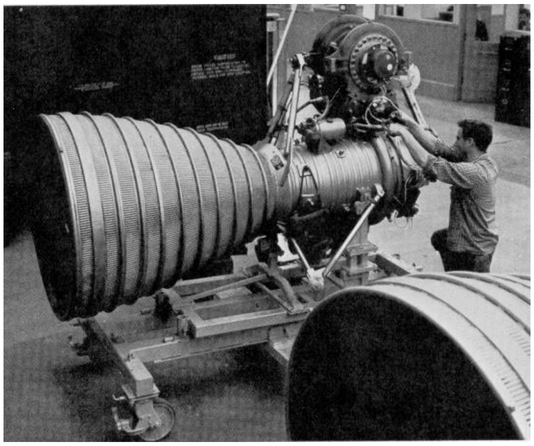
1958 followed by 30 test flights through 1963 when the rocket would become operational.

As a result of this report and the salesmanship of von Braun and the ABMA's chief General Medaris, the DoD began to take an interest in the Juno V program in early 1958. Starting in May of 1958, the newly formed Advanced Research Project Agency (ARPA) started studies of large space launch vehicles as part of their charter to lead the DoD's (and the nation's) space program. Together with IDA (Institute for Defense Analyses), ARPA began a review of the Juno V concept.

After three months of study, the ARPA/IDA team had a favorable view of the Juno V concept as outlined by ABMA except for the engine configuration. They felt that even Rocketdyne's E-1 engines would take too long to finish development. Instead they suggested that a cluster of 7 to 9 engines based on Rocketdyne's S-3D powerplant used by the Jupiter IRBM be employed to speed development. In addition, a cluster with more than six engines also allowed for a cross-feed capability where the propellant for an engine that failed in flight could be redirected to the others to compensate for the loss. This capability would partially offset the reliability concerns with so many engines. While ABMA engineers still preferred a cluster of E-1 engines, they incorporated the ARPA/IDA recommendations into their Juno V proposal as a second option.

On August 7 and 8 of 1958 ARPA leaders met with von Braun and his team at ABMA to discuss funding for the Juno V. At this point, ABMA was requesting $10.5 million to start Juno V development. In order to free up some money, ARPA immediately approved the cancellation of the Juno IV project. The Juno IV as well as the Juno III were launch vehicles based on the Jupiter IRBM that would replace ABMA's current stable of Juno I and Juno II rockets used to launch their first satellites and probes to the Moon. The Juno III was to be similar to the Jupiter-based Juno II but would use a cluster of a dozen larger solid rockets. The ARPA-funded Juno IV was to be a three-stage launch vehicle that would be capable of orbiting a payload of 230 kilograms (500 pounds). With the cancellation of these rockets, ABMA was banking its entire future on the Juno V.

On August 15, 1958 ARPA director Roy Johnson directed ABMA to start Juno V development. Two weeks later they received word that ARPA would allow $15 million to be spent on the effort - nearly $5 million more than von Braun requested. With the formal authorization and funding for the program, attention turned to finalizing the engine configuration of the Juno V. After lengthy debate during September of 1958 the question was finally resolved: The Juno V would use a cluster of eight modified S-3D engines designated H-1. The H-1 would incorporated a large number of changes to simplify its design based on experience gained from the S-3D and its sibling the MB-3 which powered the Thor IRBM. The thrust of the H-1 would be about 735 kilonewtons (165,000 pounds) with later versions upgraded to deliver 837 kilonewtons (188,000 pounds). This would initially provide the Juno V with 5,880 kilonewtons (1.32 million pounds) of thrust at lift off and as much as 6,700 kilonewtons (1.50 million pounds) of thrust on later versions. On September 11, 1958 Rocketdyne was formally awarded the contract to start development of the H-1.



The H-1 engine which was used in the Saturn. (NASA)

With this issue resolved, on September 23, 1958 meetings between ARPA and ABMA started to discuss the number of required development flights. Another subject that needed to be addressed was that of upper stages. So far Juno V consisted of a heavy-lift first stage but additional hardware would need to be built to actually send payloads into orbit. On October 13, 1958 ABMA released a report titled "Juno V Space Vehicle Development Program" which proposed four initial test flights. Static testing of the first stage would start in December of 1959. The first test flight would then take place in September or October of 1960 followed by three additional test flights over the next year. It was stressed that a choice for the upper stages had to be made soon so that the third and fourth test flight of the Juno V could be flown with them. In order to move forward, the working plan now called for the Juno V to use either an Atlas or the first stage of the new Titan ICBM as a second stage. This would provide an upper stage for the Juno V in the least amount of time.

For the third stage of the Juno V, ARPA wanted to use the USAF's innovative Centaur. Officially approved by ARPA for development by Convair on August 28, 1958, the Centaur would use a liquid hydrogen as a fuel. This high energy propellant would provide almost twice as much thrust as a like mass of more conventional fuels like kerosene or alcohol. The powerplant for the Centaur would be a pair of Pratt & Whitney LR-115 engines providing a total of 134 kilonewtons (30,000 pounds) of thrust. These engines were based on a successful design developed over several years at NACA (NASA's predecessor, the National Advisory Committee for Aeronautics) Lewis Laboratory and tested in 1957. The USAF originally planned to use the Convair-developed Centaur in combination with their Atlas ICBM to loft 4 metric tons (9,000 pounds) of payload into orbit.

Budget Problems Loom

But even as the Juno V program was beginning to move forward in the last quarter of 1958, budget problems that could affect ABMA's time table were beginning to appear on the horizon. Combined with the continued debate and uncertainty about the upper stages, the Juno V development program was in for a rough ride despite the initial enthusiasm for the project.

Against this darkening backdrop, von Braun began to push for a new name for the Juno V starting in August of 1958 to differentiate it from the older Juno-family of launch vehicles. On February 3, 1959 ARPA officially recognized the new name - Saturn.

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