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VII

GENERAL O'CONNOR'S PRESENTATION TO
THE AMERICAN INSTITUTE OF AERONAUTICS AND ASTRONAUTICS
SAN FRANCISCO, CALIFORNIA
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INTRODUCTORY REMARKS

The National Aeronautics and Space Administration's Space Program has come a long way in the last seven years. The U. S. space program was undertaken in 1958, and accelerated in 1961, because three Presidents and the Congress have considered it basic to our national strength and essential to our continued leadership of the free world. The major motivation of the space program is the necessity that we retain unquestioned preeminence in all areas of science and technology, including the new arena of space. Other motivations include the demands of national security; the potential economic benefits of space technology; the new scientific knowledge which exploration of space is yielding; the stimulating effects of this challenging national enterprise on all segments of the American society; and by no means least, the influence of our space progress on all the nations of the world--both the free nations and the bloc countries.

This morning I would like to bring you up to date on what we are doing in the Saturn launch vehicle programs and what you can expect in the future.

SLIDE 1 SATURN VEHICLES

The four launch vehicles shown on this slide are currently under development by Marshall Space Flight Center in Huntsville. The Saturn I on the left is nearing completion. Saturn IB vehicles are being readied for flight testing. The Saturn IB/Centaur program has recently been approved for design with overall systems management being assigned to Marshall. The Saturn V program is well into its ground testing phase. Let's look at each of these launch vehicles in a little more detail.

SLIDE 2 ACCOMPLISHMENTS OF SATURN I LAUNCHES

The Saturn I program, which began in 1958 and had its first launch in 1961, has been a phenomenally successful program. Of the ten vehicles planned for the program, nine have been launched to date and all nine have been successful. The one remaining is scheduled to be launched before the end of this week, at which time I'm sure our batting average will go 10 for 10.

On the last two launches, SA-8 and SA-9, we have successfully placed in orbit the Pegasus meteoroid satellites, the largest unmanned instrumented payload developed by NASA. Pegasus detects and reports the distribution and energy of meteoroids near the earth. A third Pegasus satellite is to be placed in orbit with this last flight. The information which we have received from the Pegasus satellites to date has indicated no meteoroid hazard in the vicinity of the earth that our spacecraft are not already designed to withstand.

With the Saturn I, we successfully proved the clustered engine principle, the feasibility of using liquid-hydrogen as a fuel for upper stages, and the principle of the guidance systems that we will be using in the Saturn IB and Saturn V. We also successfully tested boilerplate versions of the Apollo Spacecraft.

Perhaps the most valuable contribution the Saturn I vehicle has made is the great confidence that it has given us in our ability to obtain the necessary reliability in large boosters that we must have for our future space missions, including the manned missions.

SLIDE 3 <u>SATURN IB CHARACTERISTICS AND MISSIONS</u>

We anticipate the same success in the Saturn IB program, that we have had in the Saturn I, since the hardware technology and techniques have been flight tested and proven.

The Saturn IB vehicle has three approved missions: First, it will provide launch capability for Apollo spacecraft development and orbital maneuvers.

Second, the Saturn IB will launch the Apollo Spacecraft for crew training in the Lunar Excursion Module perfecting our rendezvous and docking techniques.

Third, the Saturn IB will serve to advance large booster technology in support of the Saturn V launch vehicle program.

Under this set of favorable conditions and performance parameters it goes without saying that the Saturn IB can and should be used to place large scientific payloads in earth orbit.

SLIDE 4 SATURN IB HARDWARE PHOTOS

The first stage of the Saturn IB is basically the same stage as the Saturn I first stage with the incorporation of improved engines, structural weight reduction, and modified tail fins which provide additional stability during flight.

Clustering has begun on the fifth flight stage by Chrysler at the Michoud Assembly Facility. The first stage is in post-static checkout at Michoud and will be shipped to Kennedy Space Center next month. Six S-IB flight stages are presently under production, the first two of which have been successfully static tested at Huntsville.

The Saturn IB second stage is also progressing on schedule with the first five S-IVB flight stages in various phases of production. The first flight stage has been shipped to Sacramento and installed in the test stand for acceptance testing. This test is scheduled to be accomplished in the next few days. The Battleship test program for S-IVB/IB configuration has been completed. The S-IVB firing you see here was a full duration test of approximately seven minutes.

The Instrument Unit located above the S-IVB stage will house some of the same components that have been flight tested on the Saturn I Instrument Unit. It will be the same Instrument Unit used on Saturn V.

Testing is under way on the ground test units at Huntsville. Components are being installed on the first flight unit by IBM in Huntsville.

So you can readily see that we have no long research and development phase ahead of us in the Saturn IB program. We will move almost directly into operational hardware in this program. With this early operational hardware, we will put into effect Dr. Mueller's "all-up" concept, in which we fly all stages and systems live on the first launch vehicle and on all subsequent vehicles.

The Saturn IB basic design requirement is to meet the mission needs of the Apollo manned program. However, in the design and development program an appropriate flexibility was incorporated to permit uprating as required to meet other mission needs should the necessity develop or to incorporate state-of-the-art improvements as they occur and are justifiable within the program.

SLIDE 5 SATURN IB IMPROVEMENT STUDIES

Our Saturn IB improvement studies show a much greater potential in payload than the present 37,000 pounds. By using a single 260-inch solid first stage and the present S-IVB second stage, we could increase the payload capability to approximately 65,000 pounds. However, by using this same solid first stage and an improved second stage incorporating a new high-pressure engine we could up the payload capability to exceed 90,000 pounds. This new engine would be a liquid-hydrogen liquid-oxygen engine with increased specific impulse and would be throttleable, designed to be a versatile engine for use in both S-IVB and S-II stage applications. I will refer to this new engine as the Optimum Engine throughout my presentation.

The third configuration is the Saturn IB with four Minuteman rockets strapped onto the S-IB first stage. This would afford about a 45,000 pound payload with the present IB or about 65,000 pounds using the Optimum Engine in the second stage.

We could use the Saturn IB configuration with eight Minuteman rockets strapped on the S-IB. This would produce a payload capability of 55,000 pounds with the standard S-IVB or 75,000 pounds with the Optimum Engine.

Still another possibility would be to use the Saturn IB with two 120-inch solid motors strapped on the S-IB stage. The payload capability with the standard second stage would be approximately 60,000 pounds and would go up to approximately 90,000 pounds with the Optimum Engine used in the second stage.

The last configuration here is the Saturn IB with four 120-inch solid motors strapped on the S-IB. This involves a "ZERO" stage where the four solid motors ignite and burn for approximately two minutes then the engines of the S-IB ignite and burn for two additional minutes.
This would give about 75,000 pounds payload capability with

the standard upper stage or in the vicinity of 100, 000 pounds using the Optimum Engine stage.

All of these combinations will present problems that will have to be resolved, but we have been solving problems since the space program began and we won't stop any time soon.

SLIDE 6 SATURN IB/CENTAUR CHARACTERISTICS

With the confidence we have in the Saturn IB vehicle, we are moving steadily ahead with the first new program based on improving it. We are adding the Centaur as a third stage to give us a versatile vehicle with a deep space probe capability. This vehicle is known as the Saturn IB/ Centaur. With the addition of the Centaur stage, we have a flexible space transportation system capable of meeting virtually all feasible missions in the payload class of 14, 000 pounds for lunar missions and 9, 500 pounds for planetary missions.

The Saturn IB/Centaur is an example of the kind of extension of the basic capability we can build into these vehicles. All our vehicles must have extended life and be capable of improvements. One mission already assigned to the Saturn IB/Centaur is the Voyager Spacecraft to Mars. Other missions are being considered.

SLIDE 7 SATURN V CHARACTERISTICS AND MISSIONS

The Saturn V is the largest of all U. S. launch vehicles being developed today. The overall height of the vehicle is 365 feet. It has a liftoff weight in excess of 6 million pounds, which is equivalent to the takeoff weight of 19 fully loaded Boeing 707 jet aircraft.

The primary mission of the Saturn V vehicle is to place the Apollo Spacecraft into a translunar trajectory for manned lunar landing. In addition to this primary mission, we at Marshall are building into the Saturn V the kind of extension capability that is built into the Saturn IB. Other earth escape missions are under study to expand our knowledge of the earth, the moon, the solar system, and the universe. Earth orbital missions are being studied for scientific research to be conducted in large manned space stations and for using satellites to improve world-wide communication, navigation, and weather prediction.

The Saturn V vehicle will serve as a work-horse for space exploration throughout the 1970's because of its versatility. It can be used as a two or a three stage vehicle. Its third stage engine can be restarted in space. These characteristics allow the vehicle to be used for diverse missions which will vary from near-earth to lunar to deep space experiments.

SLIDE 8 SATURN V HARDWARE STATUS

The first stage of the Saturn V is the S-IC being developed by the Boeing Company. The S-IC static test stage has been completed and installed in the test tower, with several five engine firings having been accomplished. These tests were conducted more than two months ahead of schedule. Also at Marshall the first two flight stages are in assembly. At Michoud, the Boeing company is assembling the Facilities and the Dynamic test stages and is fabricating components for the third and fourth flight vehicles.

The second stage of the Saturn V is the S-II stage being developed by S&ID of North American Aviation. This stage uses liquid-hydrogen technology already proven in the Saturn I second stage.

As in the case of the first stage, we are already into the static firing program with the S-II at the Santa Susana test area. The structural/dynamics test stage has been completed and is undergoing structural tests at Seal Beach with the facilities checkout and all-systems test stages in assembly.

The third stage of the Saturn V vehicle is the S-IVB stage, almost identical to the one used on the Saturn IB, being manufactured by Douglas Aircraft Company. One main difference is the aft skirt diameter which mates the S-IVB to Saturn V lower stages of larger diameter than in Saturn IB. The other main difference is the S-IVB engine for the Saturn V has an orbital restart capability to provide the Apollo Spacecraft with the coast and restart required to place it into a translunar trajectory. The S-IVB static test stage (Battleship) has been converted from the Saturn IB configuration to the Saturn V configuration and has been static tested at the Sacramento Test Site. The first two Saturn V S-IVB flight stages are in fabrication and assembly.

Above the S-IVB is the Instrument Unit. This is the brain of the launch vehicle and is designed to house the guidance systems for the entire vehicle during powered flight and orbital coast. This highly flexible system provides guidance and control for a variety of vehicle configurations and flight paths. We have completed manufacture of some test stages and are conducting tests. IBM has the integration contract for these Instrument Units, with major components being supplied by other contractors.

SLIDE 9 SATURN V IMPROVEMENTS STUDIES

As in the case of our Saturn IB, several approaches have been studied through which the Saturn V payload capability could be increased: The stages' propellant capacity can be increased; increased thrust can be achieved by increasing the number of engines; or the thrust of existing engines can be uprated. The addition of large solid motors is another approach for increased payload capability. These changes are within the present stage-of-the-art, and are relatively straightforward.

In this slide we have depicted four typical combinations of stages and engines to give a comparison of the increased payload that could be achieved.

The basic Saturn V with standard upper stage engines which has an orbital payload capability of 250,000 pounds in a 100 nautical mile earth orbit is represented here by the first red bar. By adding 50 percent Fluorine to the liquid oxygen (FLOX) in all stages of the Saturn V we can increase the payload by 35 percent, which will increase the earth orbital capability to approximately 330,000 pounds.

In the next combination we have two 156-inch solid motors strapped on the first stage. With standard upper stage configurations the payload would be increased to approximately 270,000 pounds. By substituting the Optimum Engine, which I mentioned during the Saturn IB portion, in the upper stages the capability could be increased to approximately 285,000 pounds. Then by adding FLOX to the stages the payload would go in excess of 360,000 pounds.

As you can see in the third combination, four 260-inch solid motors are strapped onto the first stage. This would involve a "ZERO" stage in which the S-IC stage engines would not ignite until the solid motors had been expended. This alone would increase the payload to approximately 700,000 pounds in earth orbit. By adding the Optimum upper stage engines the payload could be increased to approximately 800,000; then with the addition of FLOX to all stages we could yield a payload capability of approximately 900,000 pounds.

The last combination on the right involves four liquid strap-on pods. Each of these pods would contain two F-1 engines. With this you can see that the payload is increased to approximately 600,000 pounds using standard upper stage engines; to approximately 750,000 pounds using the Optimum Engine in the upper stages; and in the vicinity of one million pounds with the addition of FLOX to all stages. This last configuration has advantages over the other configurations because it can be adapted to the desired payload. By this I mean you can use the standard Saturn V; the Saturn V with only two liquid strap-on pods; or the Saturn V with four liquid pods. Another advantage is that there is no "ZERO" stage involved in this configuration.

The Saturn V will provide the United States with a greatly increased capability to explore space and exploit space technology both in earth orbit, lunar missions, and planetary missions.

SLIDE 10 SUMMARY FLIGHT SCHEDULE

In Summary: The progress of the Saturn IB has been excellant. We are on schedule to begin flight tests next year, to be followed by manned flights in 1967.

In the Saturn V/Apollo program we are also on schedule. In this program we have met and solved several technical problems. Across the board there are numerous technological problems yet to be faced, but based on experience to date we see no major delays in the Saturn V program. Our first Saturn V launch will be in 1967. Our first manned flight is scheduled for 1968. As to the first lunar landing, I can say that the program hardware and mission planning are so structured and designed that we can take advantage of any early R & D flight success, so as to make the lunar landing as early as hardware maturity, safety, and good judgement will permit.