GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

Memorandum

TO M-SAT-DIR
ATTN: Mr. ~~K.~~ K. Dannenberg

DATE ~~July 3, 1962~~ Rec'd. 7-5-62

FROM M-PIO

SUBJECT Review of Speech, "Space Vehicles for the Peaceful Exploration of the Inner Solar System," to be presented in Tampa, Florida

The subject speech has been reviewed, and there is no objection to its presentation, as amended.

Joe M. Jones
Joe M. Jones
Chief, News Branch
Public Information Office

VII

Enc:
Speech

July 62

SPACE VEHICLES FOR THE PEACEFUL EXPLORATION

OF

THE INNER SOLAR SYSTEM

By some fortunate circumstances you and I are privileged to occupy a very special place in the universe. We are gathered as a fine and forward-looking audience in a brand new university and sunny city, in the world's finest country - on a fine planet, unceasingly circling a fine young star. We meet here to review and to analyze the recent accomplishments and forthcoming plans of modern civilization and to become proud with knowledge and to rejoice in our wisdom.

We know that our fine young star is but one of the billion, trillion stars within the more than ten billion, trillion mile range of our largest telescopes. We don't know much about these stars, and what lies between and beyond; although we have at least discovered that our own solar system contains the earth as one of nine planets with their thirty moons. Everything we do know about our own solar system is exclusively derived from observations made on our planet during the last few hundred years of the Earth's short few-billion-year history. This eternity of time and the infinity of space, should put our "wisdom" into its proper place.

Mankind has been known through the ages for applying the best intellect towards the expansion of knowledge about all things. Thus, we find ourselves at present diligently occupied with some fascinating projects to explore the solar system by means of instrumented spacecraft. These experiments will unlock secrets of the universe once thought to lie beyond man's grasp. And,

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one day, man himself will go with his instruments to these distant worlds to make an age-old dream come true.

Exploration of the solar system during the next decade will concentrate on the earth, the moon, and the near planets, Mars and Venus, and of course the Sun. This paper will briefly review NASA's most active projects to explore the moon, Mars, and Venus, and then describe the launch vehicles required to accomplish these tasks.

Before I begin with my program review, I'd like to raise quickly the question: Why are we exploring Space? It is easy now-a-days for most people to see why we are interested in meteorological and communications satellites since the return from these programs will soon exceed our investment as we all know now from the newspapers. Also relatively easy can we understand the desirability of exploring space in the vicinity of the earth, and its interactions with the sun; after all, this is our own planet. Man's desire to fly in this new space environment carries the same weight of logic as the Wright Brother's first flights.

Many people, however, are questioning the need to explore the moon and the planets. There are many valid ways of answering this question; let me first quote some good reasons which I believe are particularly of interest to teachers of science and physics:

From a scientific viewpoint, we want to unlock the secrets of nature; to search for extraterrestrial life; to determine the nature and origin of the solar system; to understand our sun; and to probe all the mysteries of the universe. Everything learned from space exploration thus far indicates that the knowledge lying in wait for those who manage to observe the universe from outside the earth's atmosphere will be far grander than anything uncovered

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to date. Perhaps we shall find a clue to the destiny of all intelligent life.

During [fiscal year] FY-1962 this peaceful exploration of the solar system cost about one quarter of one cent out of every tax dollar. Thus, each of you worked about one hour during a year's span to put the program across. More effort will be required as we advance, of course, but we will be building a priceless heritage for the future, one which we can be quite proud of.

As stated before, --- the most active program is directed toward exploration of the moon. Since it is preserved in a near original state, it may offer clues to the formation of our solar system. The moon orbits the earth at only 239,000 miles distance and is therefore the most convenient celestial body for our exploration (besides the earth). Its relative proximity means that less energy is required and the opportunities to launch are far more frequent, being nearly continuous compared to every 1-1/2 years for Venus and every two years for Mars launchings. Trip times are measured in days rather than months. In addition, communicating to and from the moon is far simpler than in the case of the planets. To radio information back from Mars takes over 40,000 times the energy as to send the same information from the moon.

For "soft" landings, though, the airless moon loses much of its energy advantage since "retro"-rockets must replace the atmosphere as a braking medium. However, for return flights the small gravity field of the moon and its lack of atmosphere as well as its nearness, are of great advantage. For these reasons, the moon will be the center of attention for some time.

The exploration of the planets Mars and Venus is more difficult but of tremendous interest, as they approximate the earth environment and possibly have some kind of life. Their orbits about the sun are most like our own,

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and they are much easier to get to than Mercury, Jupiter, and the outer planets. Thus, we are concentrating our planetary exploration on Mars and Venus.

Beyond the moon, Mars, and Venus, our far-ranging spacecraft will most likely require launch vehicles and spacecraft propulsion beyond our present capabilities and will therefore be left for a second phase of our space exploration.

SLIDE #1 (SD62-716) What are we exploring?

The first slide summarizes what has been said previously.

SLIDE #2 (SD 62-718) OUR Timetable is shown on this slide (explain)

SLIDE #3 (SD 62-719) The Rockets we will use and I am going to describe in some detail are pictured in this slide.

SLIDE #4 Payload capabilities of our space vehicle are summarized in this table (read and explain) which includes also our smaller -- but all-important -- space carrier vehicles such as the Thor-based series and the solid propellant Scout -- an economical and versatile workhorse. Their missions are for the most part concerned with scientific experiments in near-space physics.

I would like now to fill you in on our medium sized and large space vehicles. I shall confine my remarks to descriptions and capabilities rather than dwell on their operational employment.

Closely tied into the development of large vehicles is the task of manufacturing, testing, and launching them. I shall also touch on these important facets of the space program. NASA's Launch Operations ~~Directorate~~ Center at Cape Canaveral is the organization that handles the firing of the vehicles we develop.

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With these introductory words let us now review the Atlas-based vehicles, then the new Titan 2, followed by the SATURN C-1 and C-5, and finally the huge NOVA.

SLIDE #5 - Atlas-based

The Atlas ICBM has been used, in a suitably modified form, to launch many Earth satellites and space probes. These modifications include removal of the warhead, strengthening of the upper neck section, and incorporation of interstage adapt or structures. Of the six configurations created -- Atlas Score, Atlas Able, Atlas Agena A, Atlas Agena B, Mercury Atlas, and Atlas Centaur -- only the latter three are still in service, and used for manned and unmanned satellite missions, for lunar hard and soft landing craft, and to project probes into deep space and to the nearer planets of the Solar System.

The Atlas Agena B and the Atlas Centaur have powered second stages; but the Mercury Atlas is a one-stage vehicle propelled only by its Atlas D engines. Although the 362,000-pound thrust of these engines is sufficient, to place the 3,000-pound Mercury capsule and the empty Atlas D into a low Earth orbit (approximately 100 miles), it cannot fly departure trajectories to the moon or the planets. These missions require multistage vehicles.

SLIDE #6 - Atlas Agena B

This two-stage Atlas Agena B is used to launch a variety of military, and scientific payloads. It can orbit large Earth satellites and place in departure trajectories lunar probes and interplanetary and planetary exploration craft. When employed as the launching vehicle for a satellite, the entire Agena B stage becomes, in fact, the satellite. For lunar and interplanetary missions it supplied the final boost velocity to its payload, which detaches

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and continues towards its destination separately. The Atlas Agena B was used to propel our Ranger spacecraft with exacting accuracy along a translunar trajectory that resulted in an impact on the far side of the moon -- without benefit of the planned midcourse correction in flight. It is being readied for Mariner R probes that we hope to launch towards the planet Venus later this year.

The Atlas Agena B consists of an Atlas D first stage and an Agena B second stage. The Atlas uses its standard three engine propulsion system plus two small vernier rockets. When modified for the Agena B mission it weighs about 260,000 pounds. With the adapter for the second stage is stands 78 feet high.

The second, or Agena B, stage is powered by a single-chamber rocket engine operating on inhibited red fuming nitric acid and unsymmetrical dimethylhydrazine. The 15,000-pound thrust engine is capable of being shut off and restarted in space. After coast and prior to re-ignition, ullage rockets provide enough acceleration to seat the propellants at the bottoms of their respective tanks. Including the Ranger adapter, the stage is 22 feet long and 5 feet in diameter. It has integral, load-carrying propellant tanks.

Components of the guidance system are the inertial reference system, timing devices, velocity meter, and infrared horizon sensor. During powered flight pitch and yaw control is maintained by gimballing the rocket motor; during periods of coast high-pressure gas jets are used.

In a lunar application the Atlas D outer engines burn for about 2 1/2 minutes before cutting off and dropping away. The smaller center engine

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continues firing for another 2 minutes, bringing the carrier to an 80-mile altitude. The two small 1000-pound thrust vernier engines fire for a period of time to trim velocity and shut off in accordance, with guidance commands. An on-board computer commands the Atlas airborne guidance system to start the timer on the Agena B stage.

Upon vernier cutoff the Atlas Agena B coasts for about 30 seconds. Then the spring-loaded aerodynamic shroud protecting the Ranger payload is discarded. Explosive charges separate the Agena B from the Atlas first stage, and retrorockets on the latter slow it down to assure it does not interfere with the second stage. The Agena B goes through a pitch maneuver to bring it in horizontal alighment to the Earth's surface. When this is accomplished, the timer sends a signal to the propulsion system and ignition occurs.

During the 2 1/2 minutes of powered flight, the stage is controlled by the hydraulic control system, with corrections being supplied by an infrared horizon-sensing device. When the Agena B engine cuts off, the Ranger payload is in a circular parking orbit approximately 100 miles above Earth. After a 14-minute coasting period, the Agena B engine relights and powers the payload for another 1 1/2 minutes, placing it in the lunar trajectory. Some 2 1/2 minutes after engine cutoff the Agena B and the payload are separated and the Ranger continues alone toward the moon.

SLIDE #7 - Atlas-Centaur on Launch Pad

The mating ofthe Centaur second stage to the Atlas first stage results in the most advanced of the Atlas-based space vehicles, the Atlas-Centaur. Here you see the vehicle on its launcher. Still in the development stage the 105-foot tall, 300,000 lbs carrier will continue to be flight tested throughout 1962 and 1963.

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Atlas-Centaur is the first known carrier to use the high-energy propellant combination of liquid oxygen and liquid hydrogen. While its first stage is powered by conventional liquid oxygen and kerosene engines, the twin-engine second stage employs this potent, frigid, new fuel combination, thus introducing a new technology that will soon play a major role in the unmanned and manned exploration of space.

This new rocket fuel develops ~~over~~ about 30 per cent more thrust from each pound of propellant consumed per second than the conventional kerosene/oxygen combination. Because of this extra energy, a carrier powered by liquid hydrogen-burning engines can carry heavier payloads longer distances than previous carriers.

The Centaur stage, like the Atlas, is 10 feet across, and therefore the forward conical section of the Atlas is replaced by a 13-foot aluminum interstage adapter with separation system.

<u>SLIDE #8 - Centaur Stagein Service Structure</u>

This slide also shows the Centaur stage being lifted into position in the service structure. The 42-feet long second stage weighs approximately 32,000 pounds not including the jettisonable nosecone and several hundred pounds of insulation discarded during the early phases of flight. Because liquid hydrogen boils off rapidly after being loaded, the tank must be adequately insulated during the loading period, as well as during the time the carrier is passing through the lower atmosphere. Four 1/2-inch thick, fiberglass quarter panels of insulation extend from the nose fairing to the point of interstage separation. They are emplaced by spring-loaded tension straps and explosive bolts. When the carrier leaves the region of high aerodynamic heating the programmer commands the bolts to explode and the panels are removed.

Difficult missions require the second stage to fire, turn off and coast, refire, coast again, and refire at a later time.

An extremely accurate, all-inertial guidance system is used to perform such maneuvers. During the coast period the guidance system becomes inactive, only a timer operating. However, before this occurs the second stage's forward section is pointed away from the Sun to reduce hydrogen boil off. Added protection is given by a fiberglass radiation shield. Since the forward end is pointed away from the Sun, the rear engine section is consequently pointed toward it. This helps to keep the engines warm during the coast periods, which is necessary at the beginning of the start sequence.

The Centaur ~~is earmarked~~ may be used to launch communication satellites, meteorological and environmental research satellites into 24 hour orbits, Surveyor probes softly onto the Moon, and Mariner craft along Venus and Mars fly by trajectories.

SLIDE #9 - Titan

There are two versions of the Titan ICBM-- 1 and 2. Titan 1, the smaller and less powerful of the two, is operational, while the brand-new Titan 2 is just entering the flight test stage. This latter carrier, shown in this slide, has been selected by NASA to boost into orbit our Gemini satellites now under development. Titan 2 has been successfully tested, but is still in early development.

In its standard version the Titan 2 is 103 feet long, 10 feet in diameter, and weighs 300,000 pounds, when fully fueled. It consists of two tandem-mounted stages, the first powered by two 215,000-pound thrust rocket engines and the second by a single 100,000-pound thrust rocket engine. All engines operate

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on a storable hypergolic mixture of nitrogen tetroxide and a combination of unsymmetrical dimethylhydrazine and hydrazine. Titan 2 is a rigidly-constructed carrier with conventional type tanks. Copper-rich aluminum alloy is extensively employed.

When the Titan 2 becomes operational, we plan to use it to orbit our 6000-pound Gemini two-man satellites now under development. In the Gemini project we will be able to practice rendezvous maneuvers in orbit to help pave the way towards successful completion of the Apollo program.

SLIDE #10 - SATURN C-1 Characteristics (Block I)

Much larger than the Atlas and Titan-based carriers are two space vehicles being developed by NASA under the SATURN Program. SATURN vehicles will be capable of sending payloads of many tons into earth orbit, to the moon, and into deep space. The main purpose of the project is manned space exploration, including the landing of men and equipment on the moon within this decade. Several versions of the SATURN have been studied. Only the principal ones are mentioned here.

The SATURN C-1 configuration consists of three stages, S-I, S-IV, and S-V. There are two so-called Block I and Block II designs.

In the Block I design, the first stage clusters eight Rocketdyne H-1 engines, each capable of generating 165,000 pounds of thrust at sea level. The four inboard engines are mounted at a fixed 3-degree cant from the vertical. The outboard engines cant 6-degrees from the vertical, and each can be gimballed for booster control. They burn RP-1 fuel--kerosene-- with liquid oxygen as the oxidizer.

The second and third (S-IV & S-V) stages will be flown as dummy stages in the first four of the programmed 10-vehicle flight test program.

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SLIDE #11 -- SATURN C-1 at Launch (Block I)

This slide shows the first launch of a SATURN C-1 booster with inert upper stages, made at Cape Canaveral October 27, 1961, ~~less~~ (little more) than three years from the beginning of the SATURN Program. During the eight-minute flight, the rocket reached a peak velocity of 3,600 miles per hour, and an altitude of 85 miles before impacting some 200 miles out in the Atlantic. Another fully successful launch was accomplished from the Cape on April 25 of this year. The cluster of eight engines generated 1.3 million pounds of thrust.

The inert upper stages were filled with water as ballast, to simulate the weight of a complete vehicle. A bonus scientific experiment was performed during the second launch. The 95 tons of water carried as ballast were deliberately released at 65 miles altitude to find out what would happen to it in the cold vacuum of space. The Project High Water experiment ~~will~~ may be repeated in the next launching.

SLIDE #12 - SATURN C-1 (Block II)

In the Block II design the S-I stage will have eight uprated H-1 engines, each capable of generating 188,000 pounds of thrust at sea level.

SLIDE #13 - SATURN C-5 Apollo (2 Stages)

After the Saturn C-1 will come Saturn C-5, or as it is sometimes called, the Advanced Saturn. Here it is shown in its two-stage version, with the Apollo Spacecraft on top. The SATURN C-5 will be 33 feet in diameter, and have a takeoff weight of ~~more than~~ nearly 6 million pounds in two-stage configuration. The first stage will be powered by five F-1 kerosene-liquid oxygen engines which yield a total takeoff

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thrust of 7.5 million pounds. This is five times the thrust of the first-stage booster of Saturn C-1. The second stage will be powered by five J-2 liquid hydrogen/oxygen engines, each one of which will provide 200,000 pounds of thrust.

SLIDE #14 - SATURN C-5 (3 Stages)

With the addition of a third stage, consisting of a single J-2 engine, the SATURN C-5 will be capable of placing 200,000-pound payloads into low earth orbit, or speeding 85,000 pounds out into deep space.

The secret of the Advanced SATURN's tremendous liftoff strength is the F-1 engine, which has in a "single-barrel" the same thrust as all eight H-1 engines -- 1 1/2 million pounds. Like the H-1, the big F-1 engine burns RP-1 fuel and liquid oxygen. The F-1 engine is not just a drawing board dream. It has been static fired by Rocketdyne in full duration tests at maximum proficiency.

SLIDE #15 -C-5 Booster

The S-IC will be the first stage of the Advanced Saturn vehicle, C-5. Powering the new booster will be a cluster of five F-1 engines, each generating 1.5 million pounds thrust. Preliminary development of the booster is underway at the Marshall Center, and a contract for its flight design and fabrication has been signed with the Boeing Company, to be produced at the Michoud Operations in New Orleans.

SLIDE #16 - S-II Cutaway

The S-II will be the second stage of the Advanced Saturn vehicle. A contract for its development and production has been signed with the Space and Information Systems Division of North American Aviation, Inc., and early work is in progress.

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The S-II, like the S-IC, will be 33 feet in diameter. It will be powered by five J-2 liquid hydrogen/liquid oxygen engines, for a total stage thrust of a million pounds.

SLIDE #17 - S-IVB Cutaway

The third stage of the SATURN C-5 vehicle will be known as the S-IVB, a modification of the S-IV stage which is used on the SATURN C-1. A contract for the modification and production of the unit is being negotiated with Douglas Aircraft Company.

The length of the new stage will be increased to some 70 feet. The power plant will be changed from six RL-10's in theS-IV to a single J-2 engine in the S-IVB. Thus the new stage will have a thrust of 200,000 pounds, compared to 90,000 in the S-IV.

SLIDE 18 - SATURN C-5 Characteristics

This slide summarizes the characteristics of the SATURN C-5. The Saturn C-1 will be used to place Apollo spacecraft carrying three men into earth orbit for up to two weeks. The C-5 will be used for sending the three-man spacecraft around the moon. It may also be used for manned lunar landings, using the rendezvous technique.

SLIDE #19 - SATURN-NOVA Comparison

Finally we come to the NOVA. Here is a comparison of the SATURN C-1 and C-5 with the NOVA. NOVA, another 3-stage vehicle, will be able to lift about 400,000 pounds into low Earth orbit or speed 150,000 pounds out into deep space. NOVA will stand about 280 feet in height, exclusive of payload, with the first stage about 50 feet in diameter.

The first stage will consist of a cluster of ~~eight~~ F-1 liquid propellant engines, generating a total thrust of 12 million pounds or more,

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Development has already begun onthe M-1 engine for the second stage.

While the Advanced SATURN will enable the lifting of a specially prepared Apollo for a flight around the Moon, the Nova will have power enough to send a fully equipped Apollo on a direct flight to a landing on the Moon, with the power to return to Earth.

SLIDE #20 - NOVA and Needle

Here is an artist's comparison of the NOVA with the Space Needle at the World's Fair in Seattle.

SLIDE #21 - Launch Complex 34

All of NASA's large space vehicles are launched from the Atlantic Missile Range at Cape Canaveral. We have quite an investment there in real estate and facilities and we are planning for more. The two Saturn vehicles which have already been successfully launched were flight tested from NASA's Vertical Launch Facility 34, which you see on the slide.

VLF 34 occupies 45 acres of AMR's 20,000 acres and was completed in June of last year. The word complex is a very good one to describe this facility, for the Saturn launch site is rather complex. The major elements of VLF 34 represent a multimillion dollar investment and include a 310-foot service tower which is sometimes call the tallest ~~the tallest~~ structure in the state of Florida ~~and the largest self-propelled, movable structure in the world~~ — although I believe the Dade County Courthouse is a few feet taller.

A new vertical launch Complex 37 is located about a mile north of Complex 34, but unlike it, will have two pads served by the same support facilities. This arrangement will permit us to launch six vehicles a year rather than four, which is the maximum number of launches permitted by Complex 34.

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SLIDE #22 - Michoud Aerial View

In conclusion, I would like to say a few words about the manufacture and testing of large space vehicles. As we were developing Saturn at MSFC, it was obvious that we would need a large fabrication and assembly building when the vehicle went into production. We found such a plant in September of last year: the Michoud Ordnance Plant, shown here, is located some 15miles east of the center of New Orleans — within the City Limits. This one-story building encloses almost 43 acres and has 1,869,020 square feet of usable floor space. During World War II, - Michoud produced aircraft; and during the Korean War, it manufactured engines for tanks.

Within this huge industrial facility the Chrysler Corporation will manufacture the S-I first stage for the SATURN C-1, and the Boeing Company will produce S-IC stages - the first stage for the Advanced SATURN.

SLIDE #23 - Static Test Tower

Closely associated with the Michoud Operations will be a huge new static test facility to be constructed at Logtown, Mississippi - only 35 miles from the Michoud plant. This site will encompass some 142,000 acres, and as many as six static test stands -- such as the one you see here -- will be constructed, capable of testing boosters with thrusts up to 20,000,000 pounds.

SLIDE #24 - Orbital Rendezvous

As we approach manned space travel involving several astronauts in interplanetary travel we must put up much bigger payloads than even our huge NOVA vehicles can carry. Our scientists have fortunately come up with another basically new concept for putting up these big payloads; instead of using a very big one-shot vehicles, like the NOVA we have plans under way to send up several smaller similar vehicles,

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assemble them and refuel them in orbit for the long haul. The principles and problems of this orbital rendezvous method are presently under detailed study and will be tested in connection with the GEMINI Program.

LIGHTS ON

CONCLUSION

As stated inthe beginning the most important benefit we will derive from space exploration is simply knowledge - new knowledge which will bring about tremendous advances in those sciences you are connected with. Each satellite and space probe and each manned flight is increasing our knowledge of our environment awaiting us on forthcoming voyages. Some of this information is reassuring, all of it increases our profound respect for that which prevails beyond the thin veil of our atmosphere.

There is also the possibility that space flight might prove to be of the greatest importance of all, and I should not be too remissed to mention this aspect of space flight in connection with the topic of my presentation here today "SPACE VEHICLES FOR THE PEACEFUL EXPLORATION OF THE INNER SOLAR SYSTEM."

A natural outgrowth of the military and prestige facets of space exploration is the question of whether this activity, in time, will replace the forces which have historically driven nations into armed conflict.

Any number of social scientists and historians have speculated that this might occur. The theory is that the conquest of space may prove to be the moral equivalent of war by substituting for certain material and psychological needs usually supplied through war; that the absorption of energies, resources, imagination, and aggressiveness in pursuit of the space adventure may become an effective way of maintaining peace.

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Put another way, nations might become "extroverted" to the point where their urge to overcome the unknown would dwarf their historic desires for power, wealth, and recognition - attributes which have so often led to war in the past.

The fact that the United Nations, late in 1959, agreed to set up a permanent Committee on the Peaceful Usesof Outer Space attests to the hopes and potential of such a development.

Of course, whether this condition will actually develop is anybody's guess. But in a world where brute force is becoming increasingly dangerous and catastrophic, the bare possibility of such a result should not be ignored by those who may be contemplating the values of space exploration. It could be the highest value of them all.