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"Birth of the Nova"
declaration of
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9/25/67

THE NATIONAL SPACE VEHICLE PROGRAM

Presented by the
National Aeronautics and Space Administration

January 27, 1959

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Prepared by the
National Aeronautics and Space Administration

In consultation with the
Advanced Research Projects Agency
of the
Department of Defense

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SUMMARY

Under the National Space Act of 1958 (Public Law 85-568) the President of the United Sates is responsible for developing a continuing program of aeronautical and space activities to be conducted by agencies of the United States. The National Aeronautics and Space Administration presents in this report a National Space Vehicle Program. This program plan is a continuing effort to be reviewed annually and revised as needed.

The National Space Vehicle Program was formulated after discussion and consultation with agencies of the Department of Defense, principally the Advanced Projects Research Agency, the Department of the Air Force, and the Department of the Army. Existing and planned projects of the Department of Defense in this area, including those intended for military missions, have been taken into account with the purpose of avoiding any unnecessary duplication of effort.

The present generation of space flight vehicles is being used to place small payloads in close orbits around the earth and to propel very small instrument packages into space. The current group of booster vehicles, namely, Vanguard, Jupiter C, Juno II, and Thor-Able, were all hurriedly assembled under pressure of meeting the threat of Russian Sputniks and none of them possess the design characteristics required by future needs of the National Space Program. The Vanguard, which has the best basic design philosophy, has not yet demonstrated sufficient flight reliability. The Jupiter C, which has had the most flight success, has

a low load-carrying capability. The Juno II vehicle has a low injection altitude for satellite use, and requires that it be spun for stability. The Thor-Able booster that has been used in the Air Force moon shots has no attitude control system for the second stage during coast, so that the injection altitude for satellites is on the order of 150 miles. The Atlas-Able being prepared for one space mission has the best potential load-carrying capability but suffers, as do the others, from being designed for a specific mission.

Our approach up to this time has been much too diverse in that we fire a few vehicles of a given configuration, most of which have failed to achieve their missions, and then call on another vehicle to take the stage. In this situation no one type of vehicle is tested with sufficient thoroughness and used in enough firings to achieve a high degree of reliability.

The National Space Vehicle Program is directed toward avoiding past errors. The central idea is that one vehicle type, when fitted with guidance and payload appropriate to the mission, can serve for most of the space missions planned for a given 2 to 4 year period. By designing the vehicle with this purpose in view and by using it again and again for most of the space work, it appears inevitable that this one vehicle type will achieve a high degree of reliability. Therefore, this program presents a series of space-flight vehicles of increasing payload capability for successive periods of use. Each vehicle of the series will be useful for satellite work including low and high circular orbits, highly elliptical earth orbits, lunar exploration, planetary exploration, and deep space probing.

In an attempt to achieve greater reliability in the existing vehicle area, NASA is sponsoring DELTA as an interim general purpose vehicle. DELTA is a more versatile version of Thor-Able, achieved by inserting a Vanguard design feature that had been deleted; namely, the coasting flight control system. Reliability rather than performance is to be emphasized by replacing or deleting those components of Vanguard and Thor-Able that have caused failures. It will be used for communication, meterological and scientific satellites and lunar probes during 1960 and 1961.

The first new general purpose vehicle of the National series is the VEGA. This is one of three vehicles based on the use of Atlas as a primary stage. The second stage is powered by the Vanguard first stage engine modified for high altitude operation. This engine has an excellent record of performance under Vanguard. The tanks are made up principally of standard Atlas parts, thus providing an early availability of the VEGA vehicle. When used for lunar or planetary missions, a third or terminal stage with solid or storable-liquid fuels will be employed. VEGA should see considerable use in the period from 1960 through 1964. It can boost two men into a close earth orbit with enough equipment to sustain them for several weeks. Its principal function, however, may be the exploration of the moon for which it is ideally suited. It should be possible in the next few years to take very high resolution photographs, first of the front or visible side of the moon and eventually of the back or heretofore unseen side. A close approach to a planet will require at least 1000 and probably 2000 pounds of equipment devoted principally to guidance and communication. VEGA is the first vehicle that can carry pay-loads of this magnitude to the vicinity of Mars or Venus and should pave the way for the use of CENTAUR which is better adapted to the planet mission.

The second new general purpose vehicle of the National series is the CENTAUR which is well suited to be a successor to VEGA, because it requires no change in the Atlas booster. CENTAUR will be useable during the period from 1962 through 1966 for performing the same missions as VEGA but with from 50 to 100 per cent more load-carrying capability. CENTAUR is the first vehicle to employ hydrogen as a fuel, and, if successful, should pave the way for use of this highest energy fuel in future vehicles of the National series. The payloads planned for SATURN and NOVA, more advanced vehicles of the National series, would have to be reduced if a lower energy fuel had to be substituted for hydrogen. There is every expectation, however, that CENTAUR will be successful, owing to the background of experience with hydrogen in industry and also within NASA.

ATLAS-HUSTLER is being developed by the Air Force. It should be available about six months prior to Vega but will have only about half of Vega's load-carrying capability. It could serve, however, as an interim version of the Atlas boosted series.

The third general purpose space vehicle of the National series is the SATURN, previously called JUNO V. Actually, JUNO V designates the first sta booster of a large multi-stage vehicle. This booster is being achieved by clustering eight ICBM-type engines and nine ballistic-missile-type tanks to form a vehicle with a gross weight of about 3/4 million pounds. Second and third stages will have to be provided in order to make a complete vehicle of SATURN. The second stage is about the size of an ICBM, will use conventional fuels at first and will be designed for high altitude operation. The third stage is smaller, and may use conventional fuels at first, but is planned ultimately for hydrogen as a propellant. This vehicle will be capable of placing very large payloads (10-15 tons) in orbits around the earth. A typical mission would involve sending a crew of 5 men into orbit with enough facilities to sustain them for a long period of time, say several months, and the necessary equipment to permit them to perform experiments and make observations.

SATURN may well become the basic vehicle for orbital supply missions, involving the transport of food and supplies to crews in orbit, the exchange of crew members, and the transport of additional fuel and equipment to the orbiting vehicle. In order to perform these latter functions, techniques of navigation and rendezvous will have to be worked out. When used for lunar and planetary exploration, unmanned of course, the SATURN space vehicle has a load-carrying capability of between 1 and 4 tons. Starting about 1963, this vehicle should see use for at least 5 and perhaps 10 years and may, in time, become one of the most versatile vehicles in the National series.

The fourth general purpose vehicle of the National series is the NOVA, an entirely new vehicle based upon use of the one and one-half million pound thrust engine recently initiated. The earliest possible use of the large engine would come about by using a single unit to propel a first stage booster. In this configuration, however, it would be about the same size as JUNO V and would be competitive to it. Therefore, the first use of the large engine is planned for NOVA; the first stage of which may employ a cluster of four of the large engines yielding a total thrust of six million pounds. The vehicle's second stage would be powered by a single million and one-half pound thrust engine and the third stage would be about the size of an ICBM but will use hydrogen as a fuel. As presently conceived, this vehicle would stand 260 feet high. NOVA is the first vehicle of the series that could attempt the mission of transporting a man to the surface of the moon and returning him safely to the earth without use of orbital supply operations.

With advances in the state-of-the-art which must surely occur over the next 5 to 10 years, it is conceivable that the NOVA would be improved to transport say 2 or 3 men on the earth-moon and return mission. Four additional stages above the three already mentioned are required for the lunar return mission including the rockets for landing on the moon, taking off from the moon, and for re-entry into the earth's atmosphere. NOVA has the capability of transporting, if it is needed, very large payloads, on the order of 75 tons, into earth orbits.

NASA is now supporting Project ROVER in anticipation of using nuclear engines in the 1965 to 1975 period. Although it is too early to designate specific uses for nuclear rocket vehicles, they would probably be employed first as upper stages for Saturn and Nova.

A wide variety of low thrust engines and vehicles can be conceived for space travel. These are vehicles that do not land or take-off from celestial bodies but are used as ferries, so to speak, between orbiting stations. The engines employ various combinations of nuclear, electrical and solar energy. Most of these engines are in early stages of development and would not see use in the near future. However, they hold promise, owing to their high efficiencies, of increased payload-carrying capabilities in the future.

Succeeding sections of this report are devoted to brief descriptions of existing vehicles and their capabilities and the plans for new vehicles and their missions.

EXISTING VEHICLES - CHARACTERISTICS

The existing vehicles are those that are now operational or that will be launched within a year. Their principal characteristics are briefly described below and the vehicles are shown on the following two charts.

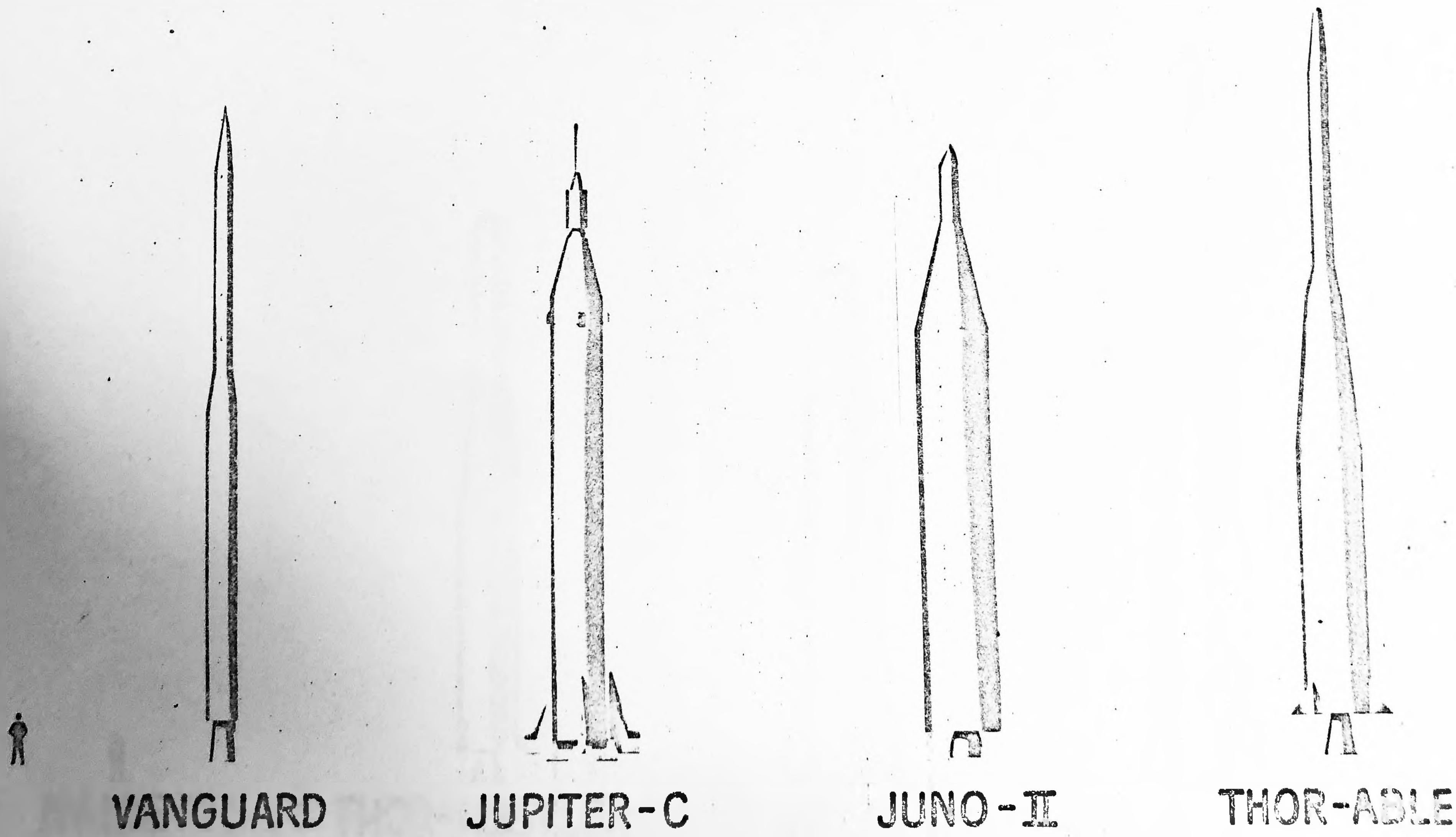
VANGUARD is the three stage vehicle designed for the U. S. - I.G.Y. effort. At launching, the Vanguard weighs 22,600 pounds. The first two stages use liquid propellants to boost the third stage and payload to orbital altitude. After the desired altitude is reached the solid propellant third stage accelerates the payload to orbital velocity. Several of the Vanguard stages appear in other vehicles currently in use such as Thor-Able and Atlas-Able.

JUPITER C is the four stage rocket which placed the first U. S. - I.G.Y. satellite, Explorer I, into orbit. The first stage of the Jupiter C was based on the Redstone which boosted the remaining three stages and the payload to orbital altitude. Stages two, three and four (made of clusters of solid rockets) accelerated the payload to orbital velocity. The latter stages were spin stabilized.

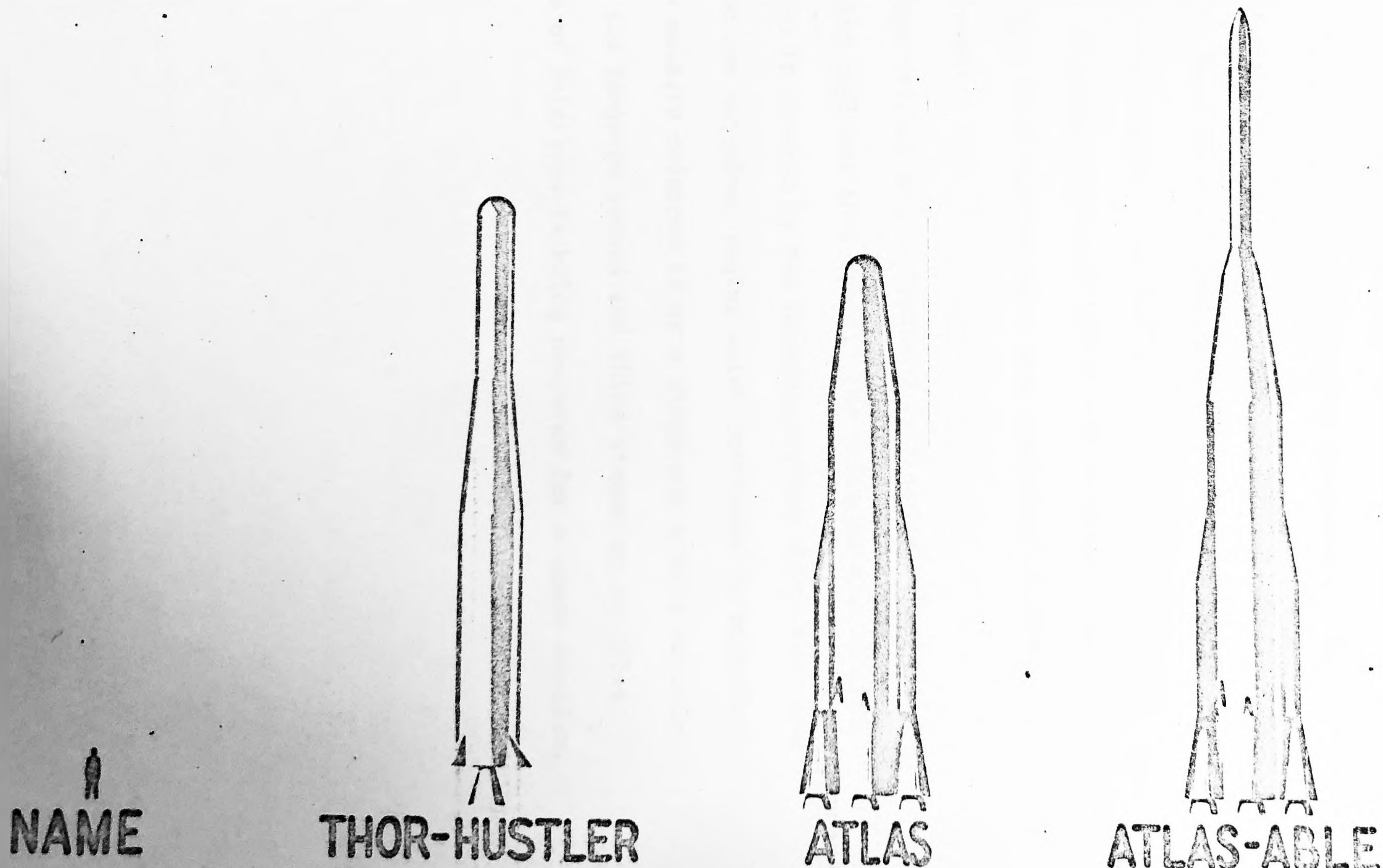
JUNO II uses the same upper stage configuration as Jupiter C. Juno II, however, employs the Jupiter IRBM missile as its first stage, giving a higher payload capability. The gross weight of Juno II is 110,500 pounds; whereas, the Jupiter C had a gross weight of 62,500 pounds.

THOR-ABLE uses the Thor IRBM as a first stage, the Vanguard second stage, (Able), and the advanced Vanguard third stage. At launching, the

EXISTING VEHICLES



EXISTING VEHICLES



Thor-Able weighs approximately 110,000 pounds compared to Vanguard's 22,600 pounds. Therefore, greater payload capability is provided. Various versions of Thor-Able are available, differing according to the mission and method of guidance.

THOR-HUSTLER is the Thor IRBM combined with a liquid propellant stage employing the Hustler engine. The Hustler second stage contains about twice the weight of propellants carried by the Vanguard second stage, (Able). Therefore, Thor-Hustler will have increased payload capabilities over the Thor-Able.

ATLAS is nearly operational and is included as a space vehicle since it is capable of placing payloads into orbit. The Atlas weighs 262,000 pounds at launching and is powered by two booster engines which separate after 135 seconds, and one sustainer engine which continues to operate. Accordingly, Atlas is usually referred to as a stage and a half vehicle.

ATLAS-ABLE uses the Vanguard second and third stages on an Atlas booster. One vehicle of this type is being prepared for a space mission.

EXISTING VEHICLES - MISSION CAPABILITIES

VANGUARD, as originally designed, is capable of placing a 21.5 pound satellite into a 300 nautical-mile orbit. Up to the present time, the vehicle has placed a 3.5 and a 21.5 pound payload into highly stable orbits. One more Vanguard is scheduled for flight with the 21.5 pound payload. Another Vanguard, using the advanced solid third stage, will carry a 50 pound payload with experiments on solar radiation, meteors, and the earth's magnetic field.

JUPITER C launched the Explorer I and III satellites which weighed 19 pounds. These satellites carried instruments to measure total cosmic ray intensity, density of meteoric matter in the satellite orbits, and temperatures both within and on the skin of the satellites. These satellites provided U. S. scientists with the first indication of the presence of a high intensity radiation belt at altitudes above 600 miles.

JUNO II has sufficient energy to place payloads of 100 pounds in a 300 mile orbit but is limited by its guidance to low perigees. Its previous use has been to launch moon probes, one of which is now in orbit around the sun. It supplied the data used in defining the great radiation belts which surround the earth. Four more Juno II vehicles are scheduled for satellite launchings. Experiments on cosmic rays, meteors, air density and structure, and the ionosphere are planned for these satellites. In addition, four Juno II vehicles are planned for launching space probes instrumented to explore the great radiation belt around the earth.

THOR-ABLE is capable of placing 400 pound payloads into an earth orbit and probing the moon with small payloads. The Thor-Able I carried the moon probe (Pioneer I) 72,000 statute miles away from earth. Several space probes and earth satellites will be launched by the Thor-Able booster in 1959. The payloads are designed for experiments in radio propagation, solar physics, radiation in space, electron and ion density, and terrestrial weather prediction.

THOR-HUSTLER is essentially a test vehicle to develop the Hustler stage. It can be used for satellite missions.

ATLAS can launch a payload of 150 pounds into a 300 mile orbit. With planned modifications, it will launch the payload of more than 2000 pounds into a lower orbit. Project Mercury will use the Atlas for initial orbital flights of the manned satellite capsule.

ATLAS-ABLE is programed for a space flight mission this year or early 1960.

INTERIM VEHICLE - CHARACTERISTICS AND MISSIONS

DELTA is a three-stage vehicle that draws heavily upon hardware and techniques developed by Vanguard and Thor-Able. The first stage is a Thor IRBM with its forward end modified to support the Vanguard second stage. The third stage is a Vanguard developed solid propellant rocket used first in the Thor-Able lunar probes. DELTA will use a new second stage autopilot and the radio guidance flown in some versions of Thor-Able. An active control system will stabilize the second-third stage combination during the long coast period between second stage burnout and third stage firing when the vehicle is used to launch an earth satellite. These features make DELTA a versatile vehicle with the capability of placing 200 to 600 pound payloads in earth orbits depending upon the altitude. It can also send about 75 pounds into space; for instance, to the moon.

DELTA will be used in 1960 and 1961 as a satellite launching vehicle. It will place in orbit meteorological and scientific instruments and the 100-foot spheres to be used as communication reflectors. Several DELTA's may be fired to the vicinity of the moon to explore lunar magnetic and radiation fields.

The succeeding figure shows the configuration and load-carrying capabilities of DELTA.

Figure
Delta Vehicle
&
Mission Capabilities

NEW VEHICLES - CHARACTERISTICS

The vehicles included in the National Space Vehicle Program are the Scout, Atlas-Hustler, Vega, Centaur, Saturn A, Saturn B, and Nova. Their principal characteristics are described below.

SCOUT is a new vehicle designed to exploit the unique properties of solid propellants and to provide a relatively simple vehicle suitable for lower altitude satellites and probes. It is a four-stage rocket employing solid rocket engines of advanced designs. The Scout will weigh approximately 34,000 pounds.

ATLAS-HUSTLER, VEGA, AND CENTAUR -- These vehicles have in common the use of the Atlas ICBM as the first stage. The differences appear in the type of second stages employed.

The HUSTLER second stage uses a 12,000-pound-thrust motor and is designed for storable liquid propellants (WFNA and Hydrazine). This stage is being tested on Thor: Project Discoverer.

The VEGA second stage uses liquid-oxygen and kerosene as propellants. A thrust of 35,000 pounds is produced by a rocket motor which is a modification of the Vanguard first-stage engine. Tankage for the Vega second stage can be conveniently constructed with Atlas tooling and parts.

The CENTAUR second stage employs a high-energy propellant combination - liquid oxygen and liquid hydrogen. A new rocket motor, suitable for this combination is now under development. Atlas tooling will also be used in the construction of Centaur tanks.

Advanced space missions require the common use of a third stage in all three vehicles. This stage will use the 6,000-pound-thrust rocket motor currently being developed at the Jet Propulsion Laboratory. In addition, a fourth stage, a low thrust solid rocket, may be required for a lunar landing.

SATURN A AND SATURN B -- With the development of the Saturn vehicles the United States will have the capability of launching vehicles that weigh 1,000,000 pounds at lift-off. The first stage will be the clustered rocket heretofore called Juno V. The Juno V employs eight rocket motors which will eventually produce a total of 1,500,000 pounds of thrust. The tankage of the Juno V is constructed of one Jupiter tank surrounded by eight Redstone tanks. The outside diameter of the cluster is 21 feet and its length is 60 feet.

The second stage of Saturn A will be a modification of an ICBM vehicle. For example, the Atlas and Titan ICBMs have been considered for this application. To employ an ICBM first stage as an upper stage, the structure must be strengthened. Modifications of Vega and Centaur could be considered as third stages for Saturn.

SATURN B is a more advanced vehicle and may use liquid-oxygen and liquid-hydrogen as upper stage fuels. Development of these high energy stages will be aided by the experience gained with Centaur.

The first three stages of the Saturn A and B vehicles will provide sufficient energy to place large payloads into earth orbits. For the more advanced missions, planet probes and lunar landings, a fourth stage having a thrust of 20,000 pounds is to be developed. This stage will employ storable liquid propellants to minimize the problems associated with transporting low-boiling point propellants long distances in space.

NOVA - The development of NOVA envisions a launching weight of at least 4,500,000 pounds. The basic building block of this vehicle is the 1,500,000-pound-thrust rocket motor. A cluster of four 1,500,000 pound motors and associated tankage may constitute the first stage of NOVA. The second stage will use one of the same 1,500,000 pound motors. Liquid-oxygen and kerosene or storable liquids are being considered for the first two stages.

In keeping with the principle of multiple usage of the rocket stages employed in the development program, the third and fourth stages of the NOVA vehicle will be based on the high-energy engines intended for use first in the Saturn B vehicle.

NEW VEHICLES - MISSION CAPABILITIES

The estimated mission capabilities of the various vehicles are described below.

SCOUT will have a range of uses such as: launching small payloads into low earth orbits, high altitude probes, high velocity re-entry tests, and providing targets for anti-missile research and identification experiments. Because of its simplicity in on site handling and transportability in the loaded condition, the SCOUT can be launched from many sites without large-scale preparations. In addition, these factors establish the SCOUT as a vehicle that could be made available to other nations for their own space research programs.

ATLAS-HUSTLER is being developed to provide satellites for operational applications. Moreover, this vehicle can carry useful payloads for scientific missions.

VEGA, with the potential of placing over 5000 pounds in an earth orbit, will allow for the establishment of a small two-man space laboratory. The laboratory could be housed in the tanks of the Vega stage with a manned capsule provided for use by the passengers during launching and return to earth. With a payload of 700 pounds available for the 24-hour orbit, experiments on communications relay satellites can be undertaken.

CENTAUR provides sufficient payload to consider manned satellites capable of glide re-entry and landings. Controlled landing of re-entry vehicles will provide greater flexibility and safety in manned satellite operations. Sufficient payload is provided by Centaur to permit installation of adequate control for landing equipment on the surface of the moon. Attempts at landing instruments on the moon may be accomplished with Vega in order to obtain preliminary data; however, the more advanced experiments on composition of the lunar surface and atmosphere and lunar seismology will require the larger payloads provided by the Centaur and Saturn vehicles.

SATURN vehicles, which have high orbital payload capability and eventually high reliability resulting from the multi-engined first stage, afford many possibilities for manned space missions. Ferry vehicles for supplying and manning permanent space stations appear as distinct possibilities with the Saturn vehicles.

Additional missions which can be foreseen with the Saturn B include the placing of large communications satellites in the 24-hour orbit and the landing of mobile robot explorers on the surface of the moon.

Saturn will also be useful in providing Mars and Venus probes of weights up to 4 tons - only a part of this weight could achieve a soft landing on a planet. The probe payload will allow for the installation of instruments, power supplies, and powerful transmitters as well as the guidance necessary for establishing more useful trajectories.

The NOVA vehicle presents a large improvement in mission capabilities over the earlier vehicles. In fact, with NOVA, a manned lunar landing and return first becomes possible, although the 2100 pound payload which returns to earth is the minimum amount which should be considered for such a mission. Moreover, advancements in techniques of guidance, re-entry, and aerodynamic braking should allow the 2100 pound figure to be doubled or tripled. The manned lunar landing will then become practical; that is, when staged directly from the earth.

NOVA will also land at least 4500 pounds on Mars, a payload which can contain instruments to study and transmit data on the Martian surface and atmosphere. A NOVA-launched solar probe weighing 4500 pounds could approach within 9,000,000 miles of the sun and perform worthwhile experiments, with the power supply and transmitter required to send data back to earth.

The NOVA vehicle could place a 43,000 pound payload in orbit around the moon and return 12,000 pounds to the surface of the earth. These payloads are sufficient to send a two-man vehicle to explore the moon from orbit prior to the attempt at a manned lunar landing.

The succeeding charts provide pictorial representations of two of the vehicles of the National Space Program.

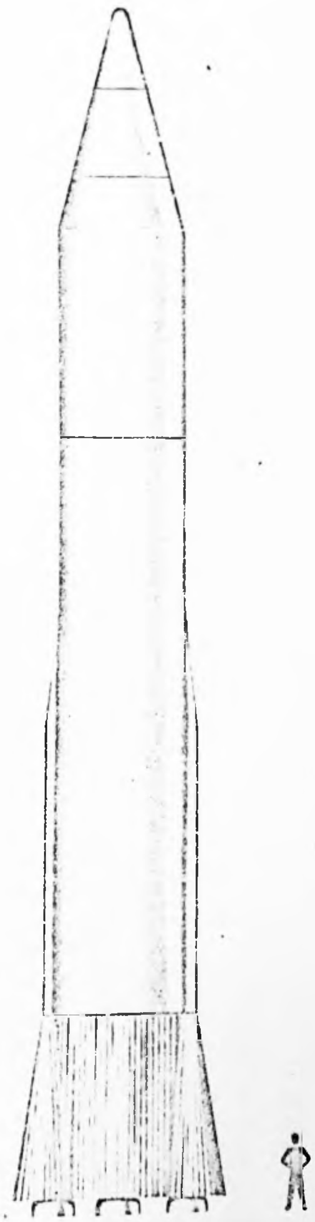
VEGA

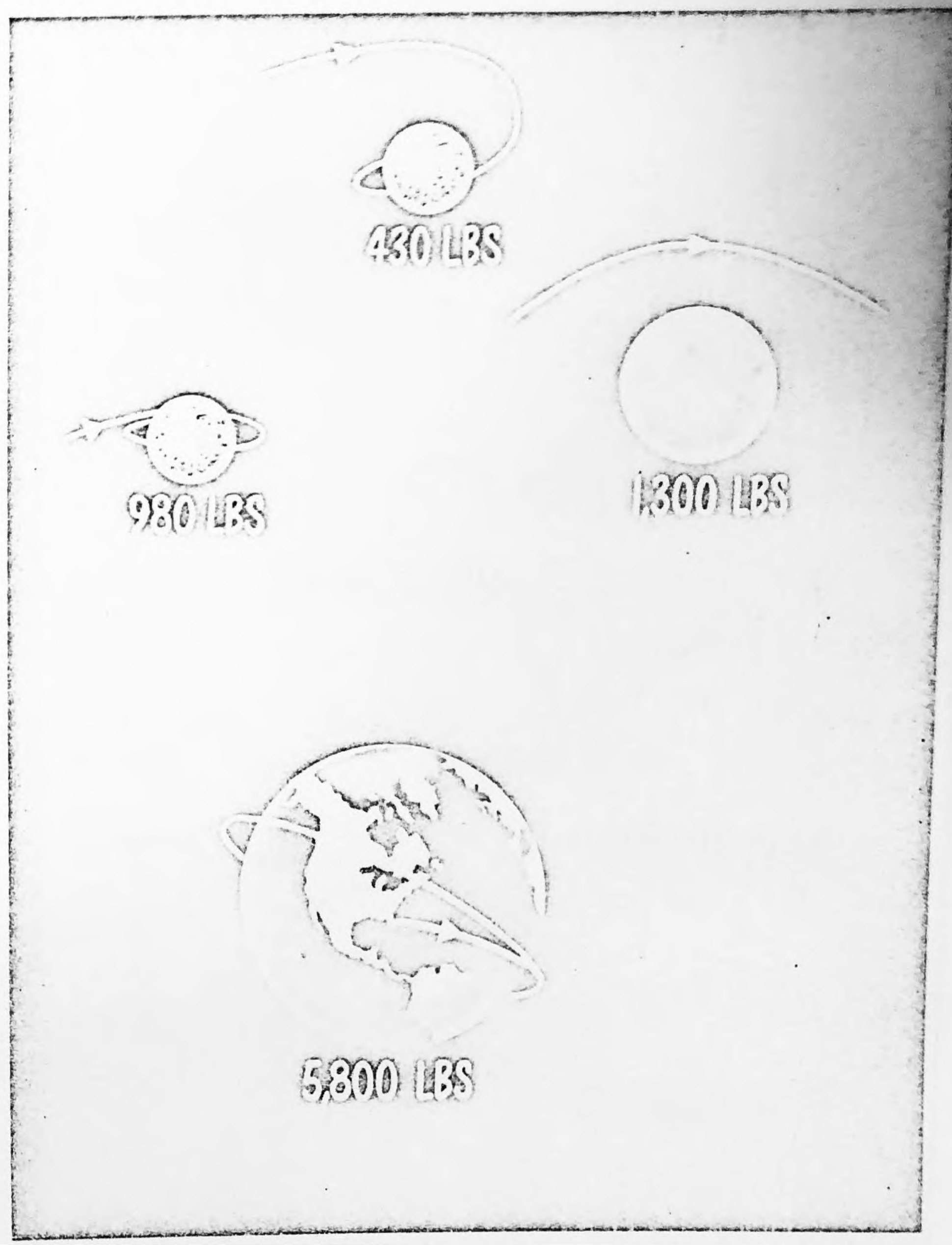
4th STAGE
STORABLE PROPELLANT

3rd STAGE
STORABLE PROPELLANT

2nd STAGE
LOX - KEROSENE
WEIGHT - 30,000 LBS.
THRUST - 33,000 LBS.

1st STAGE
LOX - KEROSENE
WEIGHT - 290,000 LBS.
THRUST - 390,000 LBS.





NOVA

5th STAGE
STORABLE PROPELLANT

4th STAGE
LOX - HYDROGEN
WEIGHT - 150,000 LBS.
THRUST - 80,000 LBS.

3rd STAGE
LOX - HYDROGEN
WEIGHT - 370,000 LBS.
THRUST - 320,000 LBS

2nd STAGE
LOX - KEROSENE
WEIGHT - 1,300,000 LBS.
THRUST - 1,700,000 LBS.

1st STAGE
LOX - KEROSENE
WEIGHT - 4,800,000 LBS.
THRUST - 6,000,000 LBS.