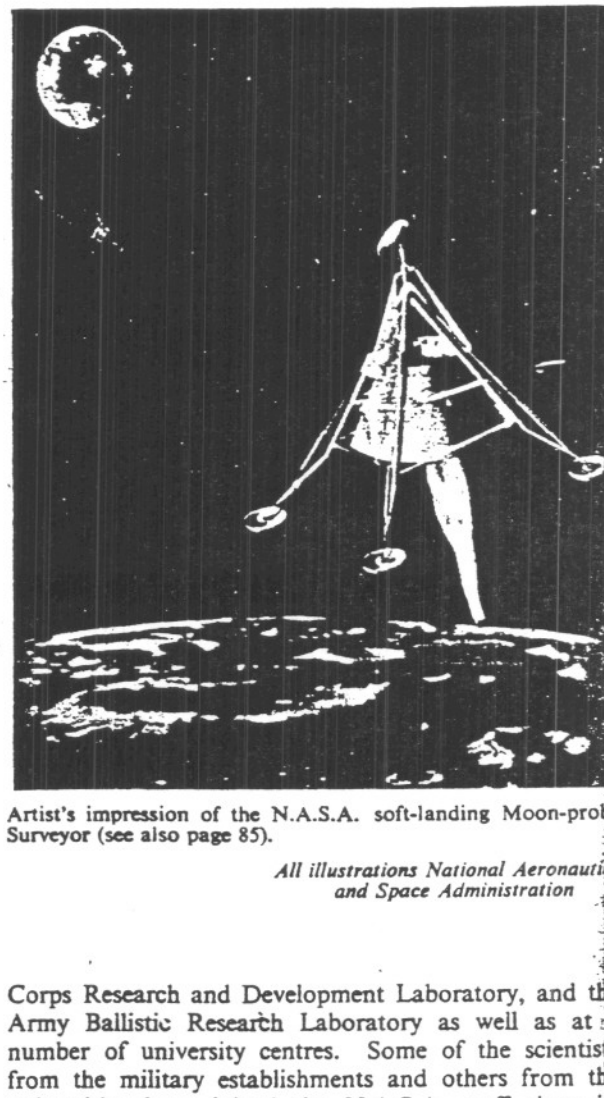
N.A.S.A. Looks Ahead*

A review of America's plans for extending space research and technology over the next 10 years.

By MORTON J. STOLLER†

Within the National Aeronautics and Space Administration, manned spaceflight, Earth satellite and sounding rocket programmes, and the development and operation of the world-wide satellite tracking and telemetry network, are the concern of the Goddard Space Flight Centre at Greenbelt, Maryland. The Jet Propulsion Laboratory is assigned the execution of unmanned lunar, planetary and interplanetary missions including tracking and data acquisition for lunar and deep space probes. The Wallops Station is used as a launching point for sounding rockets and vehicles up to and including the Scout in size. Space Flight Operations is that segment of our organization which is responsible for the world-wide complex of tracking, telemetry and communications networks. These networks include the Minitrack stations, the Baker-Nunn optical stations which are operated for N.A.S.A. by the Smithsonian Astrophysical Observatory, and the Project Mercury stations. These latter impose many special communication requirements because of the great importance of adequate real time data acquisition for the manned orbital flight mission. This office also co-ordinates the activities associated with the deep space network. This will eventually be comprised of three large data acquisition and tracking installations.

The space sciences phase of N.A.S.A.'s spaceflight programme is an outgrowth of the activity that started in 1945 when the first scientific experiments were flown on V-2 rockets captured at the end of World War II. This scientific activity was sponsored by the military services, and it eventually led to the establishment of highly competent groups of what we would now call "space scientists" at the Naval Research Laboratory, the Air Force Cambridge Research Centre, the Army Signal Corps Research and Development Laboratory, and th Army Ballistic Research Laboratory as well as at number of university centres. Some of the scientist from the military establishments and others from th universities have joined the N.A.S.A. staff since i establishment, and have been instrumental in developin N.A.S.A.'s space science programme. Our programm of scientific studies in space has three comprehensiv objectives. These are: (1) to investigate the energ transfer relations between the Sun and the Earth, or t study what are commonly known as solar-terrestri relations, (2) to probe the origin and fundament workings of the solar system and the Universe, an (3) to search for the origin and distribution of life withi our solar system. That portion of the scientific pro gramme which can be accomplished by sounding rocket near-Earth probes and satellites, is under the cognizanc of my Office. Those elements of the programme whic are concerned with lunar, interplanetary, and planeta investigations are directed by the Office of Lunar an Planetary Programmes. Within the Office of Satellit and Sounding Rocket Programmes we are engaged i studies in a number of scientific disciplines.



Artist's impression of the N.A.S.A. soft-landing Moon-prob Surveyor (see also page 85).

All illustrations National Aeronauti and Space Administration

The abridged text of a lecture given before a meeting of the British Interplanetary Society in London on 1st Oct., 1960.

†*Assisiant Director, Satellite and Sounding Rocket Programmes, N.A.S.A.*

The general nature of the experiments which can be conducted with sounding rockets is fairly well known. We generally do not expect to recover either the instrumentation or the vehicle, but we depend instead on telemetry for data recovery. There are some recovery techniques available, however, and occasionally we make use of them to recover either records or specimens from sounding rocket flights. At the moment, we are engaged in two operations requiring payload recovery. One of these is a solar flare programme in which we are attempting to launch rockets upon receipt of information of enhanced solar activity. These rockets carry energetic particle detectors and nuclear emulsions, and we expect that the analysis of these emulsions will enable us to trace in some detail the change in particle population in the upper atmosphere as a result of the solar flare. The second of these programmes also carries nuclear emulsions, in this case into the lower regions of the Van Allen belt. Low-altitude rocket operations can generally be conducted on a dry land test range for the recovery operation, but if we use high-altitude rocket systems, which ascend up to 800 to 1000 miles, the problems of dispersion and required range size make it imperative that we use water-recovery techniques.

Our satellite programme is, of course, intended to support studies in the same areas of science that we have already mentioned. With the exception of the first Vanguard satellite, which has been the subject of a number of studies resulting in new discoveries in geodesy and data on the upper atmosphere, the only scientific satellite which is still transmitting data is Explorer VII. This unit actually managed to bring together all those experiments which had not yet had a chance for successful flight in the U.S.-I.G.Y. programme. With its successful launching in October, 1959, all the I.G.Y. satellite experiments finally reached orbit. We are now within just a few weeks* of a year's flight for Explorer VII. There was installed in it a timing device to cut off the radio transmission at the end of a nominal period of 1 year. This was done so as to prevent its transmissions continually cluttering up the radio frequency channels. We will soon learn whether the timer will function properly after a year in space. (*In fact it did not.—Ed.*)

We have had some difficulties in flight with Explorer VII as one of the transistors started to shift its characteristics with temperature. As the satellite encounters greater or lesser periods of darkness, the resultant temperature variations have resulted in one of the telemetry channels failing to function properly and in recent weeks we have had trouble with the telemetry transmitter. In the main, however, it has been possible to recover data successfully and consistently from the thermal radiation experiment, the Geiger counters and the ion chamber unit.

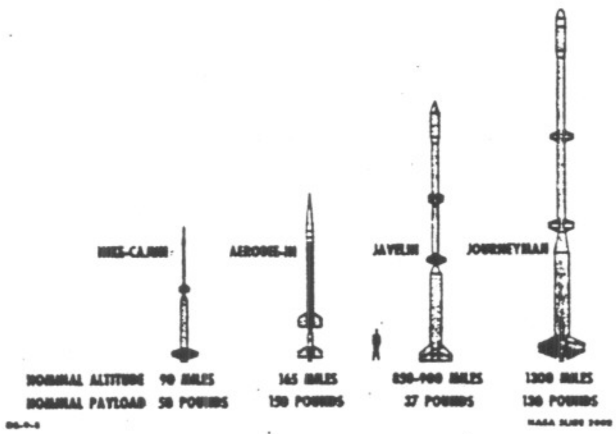
A number of satellites of the same general design philosophy as Explorer VII are due to be flown in the next few years. That is, they are of relatively light weight, somewhat between 80 and 300 lb. They may contain experiments grouped for convenience simply because they will all fit together without interference, or they may be grouped so as to make an interdisciplinary study. Some of these satellites concentrate on a single area of study, particularly where the weight limitation requires that the complete satellite be so assigned in order to conduct an effective experiment. These satellites will be flown on Juno II's, Deltas and Thor-Agenas. They cover such experimental areas as gamma-ray astronomy, direct measurements of the ionosphere, propagation measurements through the ionosphere, measurement of the radiation belts and measurement of the atmospheric structure.

Solar Satellite

The most complex of the satellites that we plan to launch in the near future is the Orbiting Solar Observatory. It consists of a large lower unit, which we call the wheel, an arm and a solar panel. Three weights which fold out increase the moment of inertia of the wheel. The arm and the solar panel are mounted on the axle of the wheel. The wheel rotates continuously and serves by its gyroscopic action to stabilize the satellite in space. There is a pointing control device which is used to rotate the satellite to such a position that the plane of the wheel cuts through the Sun. The arm is then allowed to rotate on the axle until it points at the Sun. Since the solar panel is at right-angles to the arm, the solar panel is then facing the Sun and is in a position to recharge the storage cells within the wheel. In the first version of this satellite the arm will contain two solar ultra-violet spectrographs. The wheel contains a number of experiments in solar physics and geophysics which do not need the solar pointing capability. Should the system tend to drift off the solar disc, optical pointing detectors will cause a set of gas jets at the top of the solar panel to operate. The jets are supplied from a gas bottle in the hub of the wheel. By pulsing these jets, it is possible to precess the wheel and arm back into solar alignment. A fine pointing control for the arm is also provided.

*When the lecture was originally presented on 1 Oct., 1960.

TYPICAL SOUNDING ROCKETS



We hope to use the basic structure of this observatory, with its pointing controls and dual telemetry included, several times in the course of the next few years. The experiments will change but the wheel and arm structure and the pointing controls will remain the same.

In this respect, the satellite spacecraft programme is being directed in a manner similar to that of the launching vehicle programme; that is, we are attempting to reduce the number and varieties of shape and size of our satellites. We believe that we can reutilize a given spacecraft a number of times before undertaking a major re-design. In this way, we expect to save a great deal of engineering effort as well as achieving an increase in system reliability.

The natural next step in this repetitive use programme is the spacecraft we have designated as the Orbiting Geophysical Observatory. For this, we envisage a central body which contains the instruments, the common telemetry, the command receiving system, and all the other devices (we call them housekeeping devices) needed to adjust and report on the internal conditions of the satellite. On the outside are attached the large solar panels, and several booms or extendable arms, to which those experimental sensors which have to be isolated from the main body or mass of the satellite are attached. We expect to launch these geophysical observatories into both near-Earth almost circular polar orbits, and in highly eccentric orbits out to some 60,000 miles or more. We hope to use the same spacecraft structure repetitively for both near- and far-Earth orbits. The Thor-Agena is an adequate vehicle to handle the near-Earth polar orbit with a spacecraft weight of about 1000 lb. The Atlas-Agena would be required for the highly eccentric orbit and the spacecraft weight would have to be somewhat less. There is to be a potential for growth in weight in the payload design and it is expected that the Centaur vehicles will eventually be used to launch the same spacecraft, with the greater weight, into the high apogee orbit.

The scientific satellite programme will also make use over a period of years of an Orbiting Astronomical Observatory. This will be far more complex than either the solar or the geophysical observatories. It will ha[v] provisions for precise pointing control and relative elaborate data handling devices. The central core this observatory spacecraft will be an interchangeab instrument container which will enable us to prepa several different sets of experiments for flight in t basic structure. The capacity of the system will be su that a mirror up to 36 in. diameter can be installed in t central element. The experiments we are planning f this vehicle include an ultra-violet sky-mapping surve multi-colour ultra-violet photometry of stars, lo dispersion stellar ultra-violet spectroscopic studies, abs lute ultra-violet spectrophotometry of both stars a extended emission regions, and finally a very hi resolution ultra-violet spectrometer will be used examine in detail the absorption effects of the interstell medium. The last of these experiments will requ extremely high precision pointing stability and for t reason provision has been made to take advantage of t signals from the optics that the experimenter w provide, to drive the sensors which will control t direction of the optical axis of the observatory. Und these conditions we hope the unit will be stabilized a fraction of a second of arc. There will be a comma control system and an internal stored programme dev which will make it possible for the experimenter to lo the satellite-borne memory of the programmer w instructions to point to successive stars in the course an orbit and to store the data collected in the course that orbit in a separate memory. When the satellite on again reappears over the master control and telemet station the memory devices will be read out to the grou receiving equipment and the programming unit will reset for the next cycle of operation. Should there be failure of these devices provision has been made for dir real time data read out and control.

We expect to launch an average of about one hund sounding rockets a year by 1962, and to launch six nine small satellites a year for the present, this numb becoming about six per year by 1963. The large satelli class includes the larger solar, geophysical and astrono cal observatories. About four launchings of this cl per year by 1964 are being planned.

The second major area of the space science portion our programme is the lunar and planetary section. 1962, three Ranger vehicles are planned for flights impact the surface of the Moon. These will be follow by the soft-landing mission. "Surveyor" and "Pr pector" have been chosen as designations for spacecr in this series. It is possible that a more compl investigation of the lunar surface characteristics by the use of an advanced lunar orbiter may precede surf exploration with a mobile vehicle.

It would be expected that the instrumented lu programme would eventually evolve into the mann programme of lunar exploration, although it is like that unmanned payloads will be continued at some lev for an indefinite period.

In the planetary programme, "Mariner" spacecraft are planned for Mars and Venus fly-bys at the first practical opportunity. The interplanetary environment will be studied en route. "Voyager" spacecraft, using the Saturn vehicle, are being considered for advanced planetary orbiters. Planetary landing vehicles, flights for solar studies, and investigations out of the plane of the ecliptic will have to await the development of vehicles with adequate capabilities. Development and study for these missions will continue over a period of years.

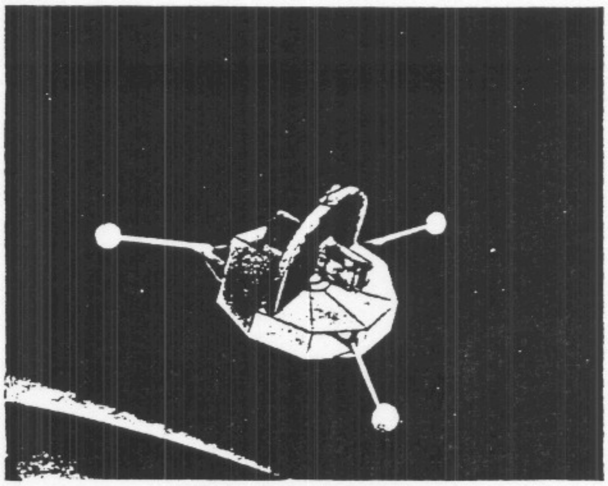
Ranger and Mariner.

Spacecraft are being planned for use on lunar, planetary and interplanetary missions with gross weights varying from 600 to 1200 lb. One particular variant will be used on interplanetary missions launched with Atlas-Agena vehicles in an early phase of Project Ranger. Although the primary purpose of these flights is to test the spacecraft and component developments, a set of seven scientific experiments has been included. A version differing primarily in the instrumentation carried will, we hope, be used on the early planetary missions to Mars and Venus under Project Mariner.

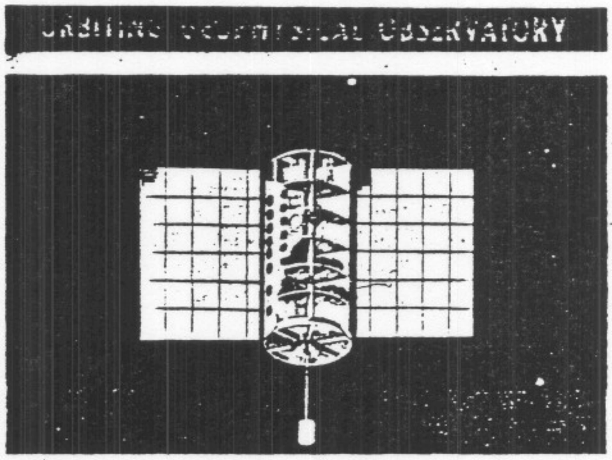
The lunar impact missions, which conclude Project Ranger, will also use a modified version of this spacecraft. This version is being designed to carry a survivable capsule containing a seismometer as the primary experiment. The spacecraft is being developed by the Jet Propulsion Laboratory, while the capsule is under contract to the Aeronutronics Division of Ford Motor Company. The Ranger flight plan is shown on this page. During the early stages of the flight, the spacecraft is designed to maintain three-axis attitude control with its antenna pointing toward the Earth and its solar panels toward the Sun. Radio tracking will reveal any necessary course corrections, which the spacecraft will then make on command by orienting itself for a mid-course rocket firing and then reorienting itself with its principal axis toward the Sun for travel through cislunar space. As the spacecraft approaches the lunar surface, it will orient itself on command along the vertical descent path and will begin to take high resolution television pictures and will activate a gamma-ray spectrometer. At the lowest possible altitude the survivable capsule will be slowed by retrorocket for a rough but safe landing. The main spacecraft will be destroyed on impact.

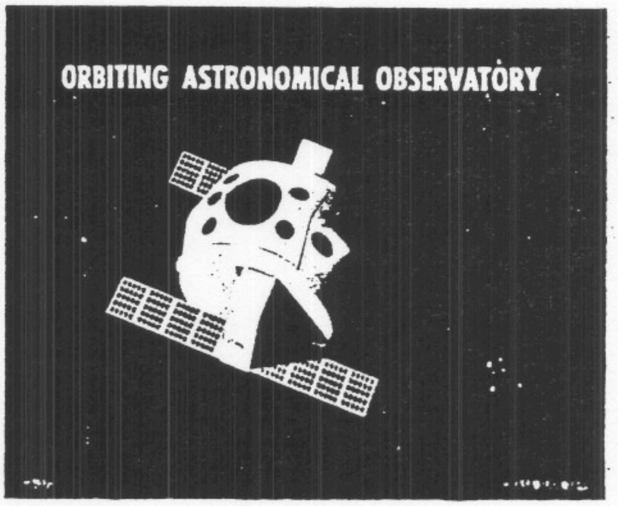
The two spacecraft types just described are well along in development, as are their scientific payloads, with the exception of some of the planetary probe instrumentation. The following spacecraft for the more advanced missions are still in the planning stage.

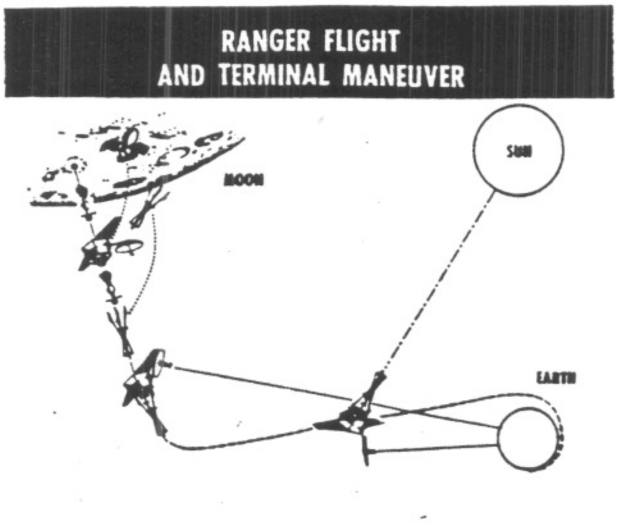
The next spacecraft to be undertaken as part of the lunar and planetary programme is Surveyor. It is designed for the lunar soft-landing mission using a Centaur launch vehicle. Intended to deposit a moderately heavy (100 to 300 lb.) scientific payload on the lunar surface, it is designed to test for the existence of local fields or atmosphere, and would also examine the

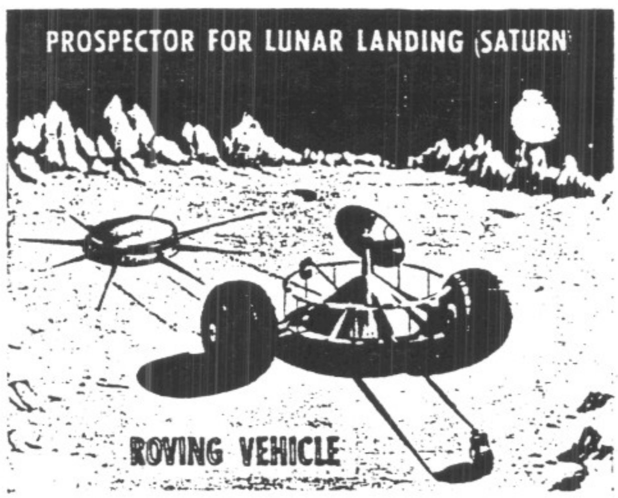


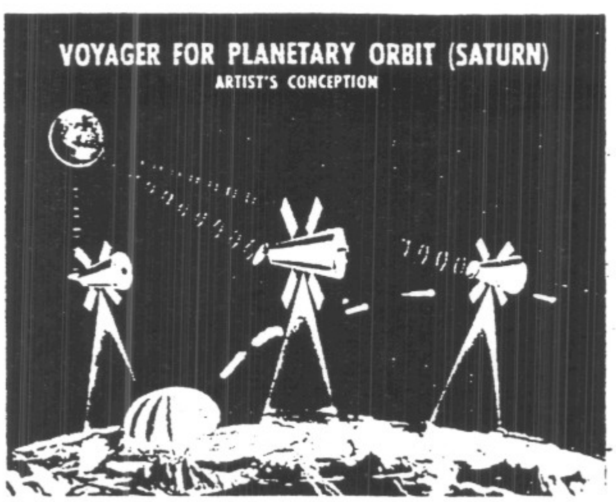
Orbiting Solar Observatory











surface and subsurface characteristics with a variety instruments, including television, spectrometer, seis ometer, magnetometer, and others.

Mobile Surface Probe.

The lunar soft-landing spacecraft for Saturn (Pr pector) is currently under study by the Jet Propuls Laboratory, and by the Marshall Space Flight Cen for J.P.L. As now envisaged, the Prospector spacecr would consist of a soft-landing "truck" plus seve alternative payloads. This mobile laboratory would h first priority as a Prospector payload. It would capable of exploring throughout a radius of perh 50 miles, terrain permitting, and would obtain orders magnitude more data than could be obtained w Centaur stationary spacecraft. It is anticipated that mobile vehicle would be used in areas of particu interest as highlighted by previous flights with Centa

The Voyager series is conceived as being launched w the Saturn vehicle to orbit Mars and Venus. The spa craft would be designed to eject an instrumented caps for atmospheric entry and perhaps landing. Data fr the capsule could be stored and relayed by the mot craft or, technology permitting, could be received dire on Earth.

Satellite Meteorology.

N.A.S.A.'s spaceflight applications programme has basic facets at present. One is meteorology and the ot is communications. The success of the Tiros I and meteorological satellites is well known. The possibili of expanding the satellite cloud cover and infra- survey programme into an operational meteorolog programme have been already discussed by oth Beyond Tiros, N.A.S.A. plans to develop the Nim series of meteorological satellites. These are expecte weigh 600–700 lb. and will be put into orbit with Th Agena B launch vehicles. They will have a stabilizat system to keep the cameras and other sensors poi earthward at all times. The sensors will include cameras, passive and scanning-type infra-red radia sensing equipment and other experiments. A solar and storage battery power supply will be incorpora The Nimbus spacecraft project is beginning and estimate that the first unit will be flown in 1962.

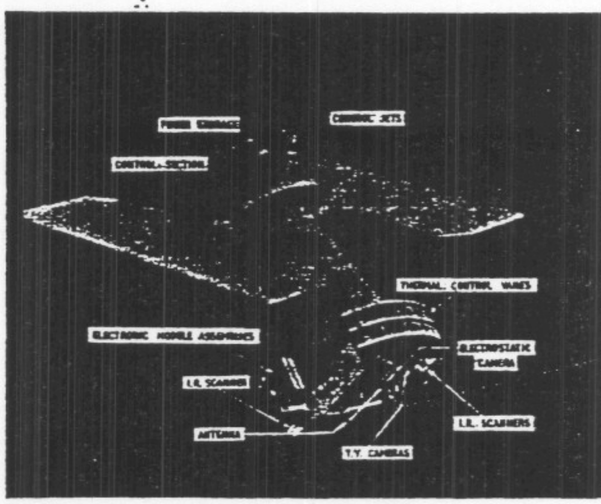
In the second of the two applications areas, comm cations, we have been working primarily on pas satellite techniques. The 100-ft. spherical reflector, E is the first satellite in this programme. Satisfac voice, teletype and continuous wave transmission h been made between the indicated stations and betw other pairs of stations in the United States. Tr missions between the United States, England and Continent have also been accomplished. The satelli made of half-mil thick mylar which has been coated both surfaces with evaporated aluminim. It carries instrumentation other than the two small radio bea which are used to aid the tracking system to ob orbital co-ordinate data. Echo I has already been used by the various stations to take a large volume of data on propagation characteristics and has given us a first-hand view of the problems involved in continuously pointing high gain antennas at such a satellite during its periodic passages. The follow-on programme in communications will include work on a rigidized passive reflecting unit and initial studies of the active repeater satellite.

Man-in-Space.

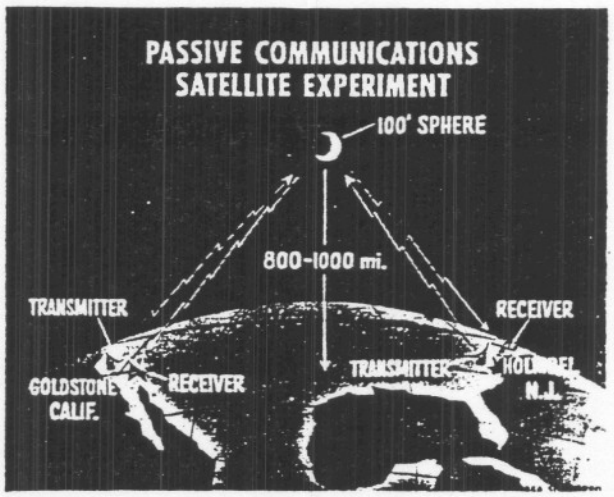
N.A.S.A. has a single broad objective for its manned spaceflight programme. That objective is to provide the capability for manned exploration of space. With this objective in mind, a programme has been outlined in general terms, though it has not yet been officially approved. It represents the thinking of the technical staff responsible for planning the long-range development programme leading to the manned exploration of outer space. The initial step is Project Mercury, a project designed to put a manned satellite into orbit about 120 miles above the Earth's surface, let it circle the Earth three times, and then bring it back safely. We are carrying out Mercury so that we can get some understanding of the problems involved in manned spaceflight before we embark on more ambitious missions. Project Mercury is the simplest way to learn what we need to know about man's capabilities in space at the earliest possible date.

The accomplishment of Project Mercury will mark a tremendous step forward; man's venture into space will immeasurably extend the frontiers of flight. The speed of flight will be increased by a factor of 8 over present achievements, and the altitude by a factor of 5; the environment encountered in spaceflight is one that heretofore has not even been approached. This extension of the flight envelope has required major technical advancements in many diverse fields, including aerodynamics, bio-technology, instrumentation, communications, attitude control, environmental control and parachute development—to mention only a few. By its very advanced nature, therefore, Project Mercury has opened the door for the next step in the manned spaceflight programme.

The next step involves the development of manned spacecraft designed to allow man to perform useful functions in space. We believe this spacecraft should ultimately be capable of manned circumlunar flight as a logical intermediate step toward the future goals of landing men on the Moon and the planets. The design of the spacecraft should be sufficiently flexible to permit its use as an Earth-orbiting laboratory. This is a necessary intermediate step toward the establishment of a permanent manned space-station. Therefore, our present planning calls for the development and construction of an advanced manned spacecraft with sufficient flexibility to be capable of both circumlunar flight and useful Earth-orbital missions. In the long range, this spacecraft should lead toward manned



Configuration of the "second generation" meteorological satellite, Nimbus.



Experimental Communication system using the 100 ft. dia. balloon-satellite Echo I.

landing on the Moon and planets and toward a permanent manned space-station. This advanced manned spaceflight programme has been named "Project Apollo."

It will be be noted that the proposed manned circumlunar flight is a mission consistent with the planned booster capability, that is, with the Saturn vehicle Before circumlunar missions are attempted, Earth-orbital flights will be required for spacecraft evaluation, for crew training, and for the development of operational techniques. In conjunction with, or in addition to these qualification flights, the spacecraft can be used in an Earth orbit as a laboratory for scientific measurements or technological developments in space.

In order to achieve this multiplicity of missions, it may be desirable to employ the so-called "modular concept" in the design of the advanced manned spacecraft. In this concept various building blocks or modules of the system are employed for different phases of the mission. Basically, the spacecraft is conceived to consist of three modules: the command centre module, the propulsion module and the mission module The command centre would house the crew during the launch and re-entry phases of flight. It would also serve as the flight control centre for the remainder of the mission. We anticipate that this module will be identical for both the circumlunar and Earth-orbital missions.

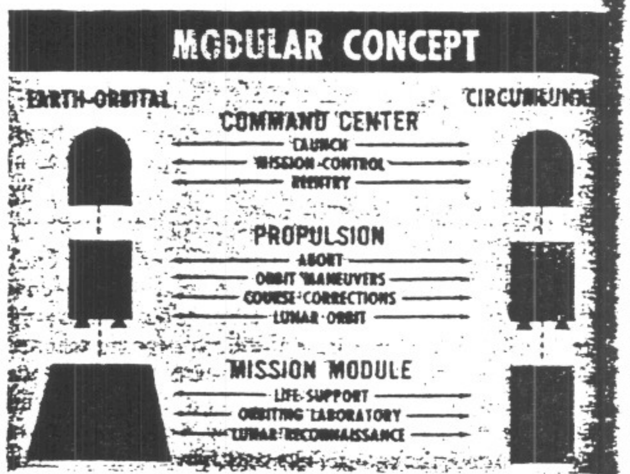
The propulsion module would serve the primary function of providing safe return to Earth in case of an aborted mission. In this sense, it might be compared with the escape tower and retro-rockets on the Mercury capsule. In addition, for circumlunar flight, this component should have the capability of making mid-course corrections; it might also be used to place the spacecraft into an orbit around the Moon and eject it from that orbit. In an Earth-orbital mission, the propulsion module should permit a degree of manœuvreability in orbit for rendezvous with other vehicles. Once again, it may be desirable to provide identical propulsion units for both orbital and circumlunar flights.

The command centre and propulsion units together might be considered, for some applications, as a complete spacecraft, even without the mission modules.

The mission module would differ for the various flight missions. For circumlunar flight, it would be used to provide better living quarters than the command centre can afford, and some equipment for scientific observations. (Detailed design studies may well indicate that the command centre and circumlunar mission modules should be combined into a single package.)

For the Earth-orbital flight, the mission module can be considerably heavier than for circumlunar flight. Hence this module can usefully serve as an Earth-orbiting laboratory, with adequate capacity for scientific instrumentation and reasonably long lifetimes in orbit.

Of all the modules mentioned, only the command centre unit would be designed with re-entry and recovery capability. This module must be designed to re-enter the Earth's atmosphere at essentially parabolic velocity,



Apollo Project.

or about 36,000 ft./sec. It will have to withstand th severe heating encountered at these velocities, and must be statically stable over the entire speed range fro 36,000 ft./sec. to the landing speed.

A degree of manœuvreability will be required to st within the limits of a rather narrow flight corridor. Th boundaries of this corridor are determined by maximu tolerable loads or heating, on the one hand, and minimu aerodynamic loads to cause re-entry in a single pass, o the other. The amount of manœuvreability can b minimized through the provision of adequate mid-cour propulsive corrections.

The manœuvreability provided for corridor contr should also permit a landing at a fixed point (or withi a small area) on Earth. A conventional airplane-ty landing is not required. Instead, vertical landings usi parachutes or other devices are acceptable. Because the world-wide aspects of these missions, the vehic must be capable of surviving both ground and wat landings.

An important design consideration is that safe recove must be possible for both normal and aborted missio As in the case of the Mercury capsule, it is expected th the most severe requirements will stem from some of t off-design conditions.

There has been a great deal of discussion concerni the role to be played by the pilot in a space missio Under the assumption that Project Mercury will demo strate that man can indeed perform useful functions i space, we believe that in all future missions the prima control should be on board the spacecraft.

This guideline is not to be construed as implying th there would be no automatic guidance or control system on board. Certainly, there are many functions that c better be performed automatically than manually. Bu the basic decision-making capabilities, and some contr functions, are to be assigned to the man.

Because of the possibility of a catastrophic failure o any of the Saturn stages, the spacecraft must be equipp with sufficient propulsion to permit safe crew recover from aborted missions. Such capability must be provided for an abort at any speed up to maximum velocity and should be independent of the launch propulsion system.

Some of the requirements for the propulsion module are summarized as follows:

Primary requirements:
- Safe recovery from aborts.
- Course corrections.
- Return from orbit.

Secondary requirements:
- Lunar orbit.
- Manœuvreing in Earth orbit.

Preliminary studies have indicated that, for a circumlunar mission, roughly one-third of the permissible spacecraft weight will be required for onboard propulsion.

In a normal mission, this same propulsion may be applied for course corrections, both while approaching the Moon and when returning to the Earth. As mentioned earlier, the propulsion that must be carried for emergency considerations may, in a normal mission, be sufficient to place the spacecraft into a satellite orbit around the Moon.

For the Earth-orbital mission, the propulsion module would again serve the primary function of providing safe return capability from an aborted mission. If it is not needed for this purpose, then the available impulse might be used for manœuvreing in orbit and for orbital rendezvous with other satellites.

We have tentatively specified that the advanced manned spacecraft should be designed for a three-man crew. Our concept is that, during launch and re-entry, this crew would be located in the command centre unit, but, for the remainder of the fight, at least two of the crew members would be in the mission module.

The use of a pressure suit in the command centre module may be acceptable. But the mission module should definitely be designed to permit "shirt-sleeve" operations, that is, operations without the use of pressure suits. We believe that pressure suits, as currently envisioned, would not be acceptable for the duration of a circumlunar flight.

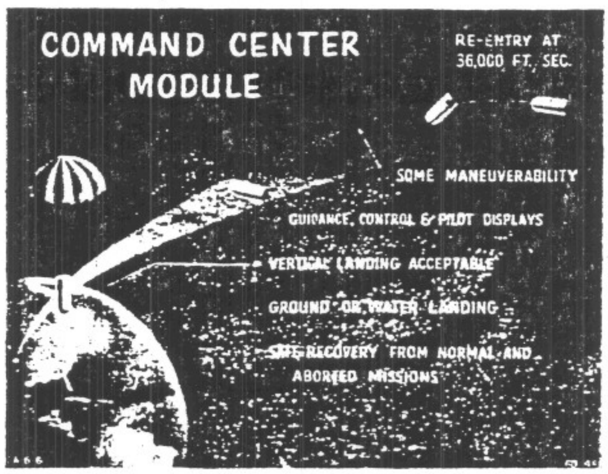
The foregoing requirements apply for both the circumlunar mission and the Earth-orbital mission However, there are other requirements that differ widely between the two types of flight For example, the circumlunar mission module requires an environmental control system that need only provide for about 1 week's life support; on the other hand, it may be desirable to keep the Earth-orbiting laboratory in space for periods ranging from 2 weeks to 2 months.

The circumlunar module would carry only the minimum amount of instrumentation required to complete the mission, whereas a great deal of instrumentation for scientific measurements and observations should be provided in the orbiting laboratory.

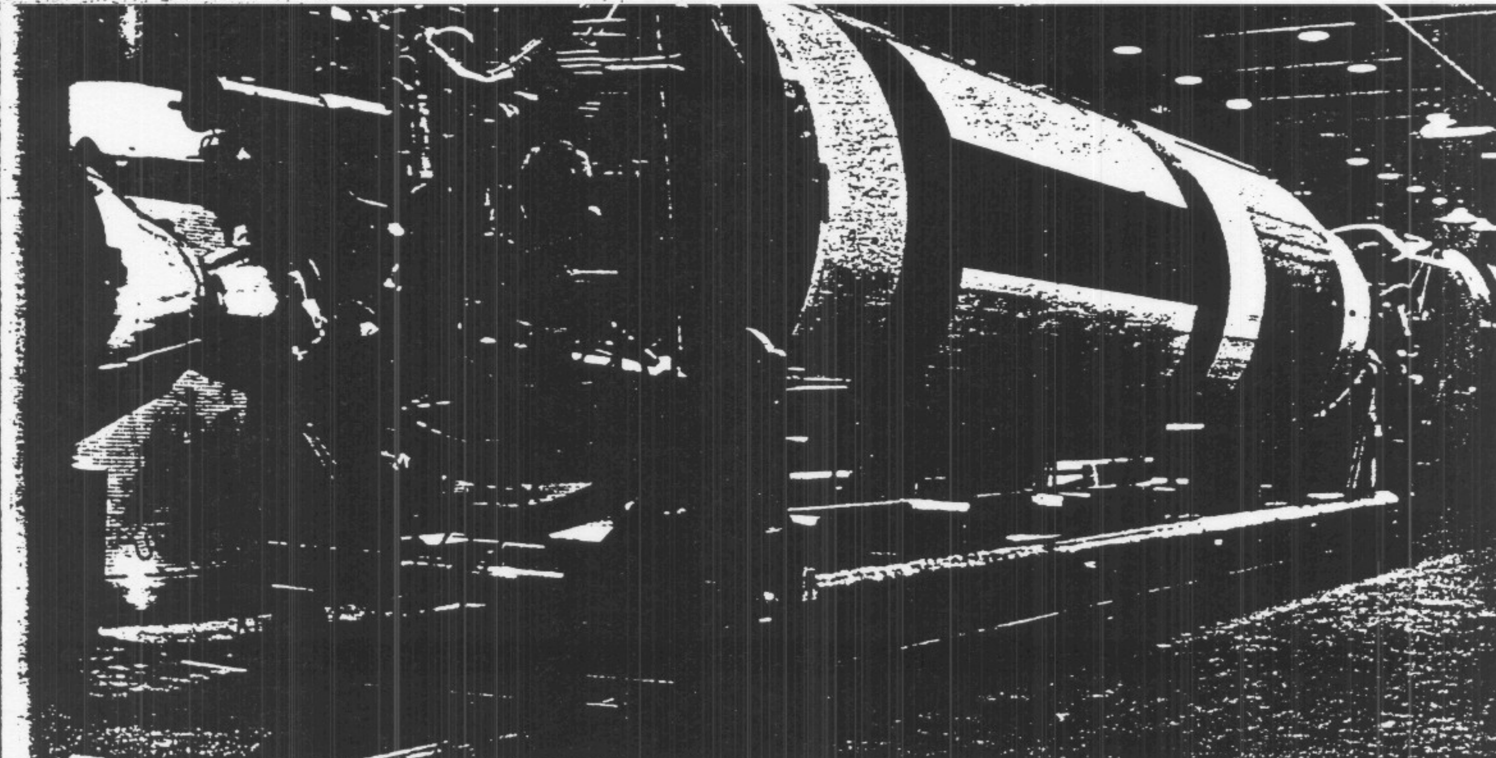
The N.A.S.A. centres and industrial contractors have been invited to participate in a programme of system design studies related to Project Apollo. According to the present plans, the systems contracts for the design, engineering and fabrication of the manned spacecraft and its components will probably be initiated in Fiscal Year 1962. However, it should be emphasized that this programme has no official standing as yet. Provision for the initiation of N.A.S.A.'s manned spaceflight programme, beyond Project Mercury, is expected to be included in the Fiscal Year 1962 budgetary request which will be sent to the Congress in January, 1961. With that statement as a basic premise, our present thinking is outlined as follows: Major Mercury flights will probably continue for several years. Research and development, and prototype flights of the advanced manned spacecraft would start in 1962 and to end in 1965. Early flight in in this series would be used to verify final design criteria for the spacecraft shape and its heat protection. It is planned to use the Atlas-Agena B as the launch vehicle for these missions. Following the Atlas-Agena flights, the Saturn vehicle would be used for full-scale development and prototype flights Earth-orbital missions, using the final spacecraft, could conceivably begin in 1966, with circumlunar missions following as soon as the state of both technical and aeromedical knowledge permits such flights.

In summary, our spaceflight programme activities include the space sciences, applications of spaceflight capabilities to projects of direct interest to the general community and the Mercury project to develop the capability for manned exploration of space. In support of these there is an extensive launch vehicles programme. The vehicles programme is endeavouring to increase the reliability of our operations by making repetitive use of a limited number of vehicle systems. The same concept is being worked into the spacecraft planning.

All of this work rests on the broad vase of research and development, in a multitude of specialized scientific and technical fields, which is conducted by the industrial and scientific communities, the military services and N.A.S.A.'s own centres. Without their contributions our plans and programmes would have little substance.



Apollo Project



VOL. III No. 3 **CONTENTS** MAY 1961