The shape of tomorrow

NASA's Ranger project, already in the hardware stage, readies for missions to cislunar space, the lunar surface, and planets Mars and Venus . . . lunar soft-landers and orbiters under design

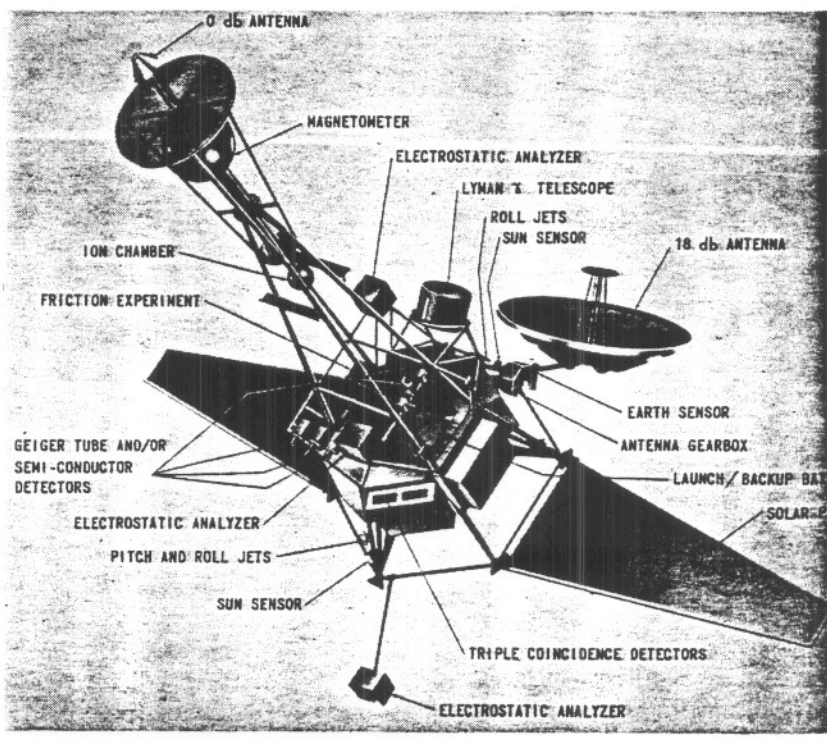
By Clifford I. Cummings

JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY, PASADENA, CALIF.

Clifford I. Cummings is Ranger and Lunar Program Director at JPL. Since receiving a B.S. in physics from CalTech in 1944, he has held a succession of positions with JPL— project leader for WAC Corporal and Corporal missile telemetering systems and range instrumentation, project leader for Corporal guidance, technical coordinator for the complete Corporal system, project director of JPL's portion of the Jupiter program, and head of the systems engineering division. In January 1958, Cummings took leave of absence to join DOD's Weapon Systems Evaluation Group, and then in June of 1958 to become a member of the ARPA staff. In January 1959, he became JPL's representative at NASA headquarters, and then in June 1959 returned to JPL in his present assignment.

EXAMINE the literature on our moon and the planets Mars and Venus and you will find that we indeed have obtained a great deal of knowledge about them without having left earth. We know their sizes, masses, orbital periods and inclinations, relative distances and velocities, and other basic celestial-mechanic features.

But there obviously is much we do not know. For instance, because we cannot see through the atmosphere of Venus from the earth, we have not yet been able to find out its rotation period or the tilt of its axis of rotation, or even come to a reasonable conclusion regarding its cloud-shrouded interior, whether it has any land masses or is all covered with some liquid.



Initial Testing Version of Ranger Spacecraft

Also, although we have a great number of facts about our own planet, we still look forward to the information which we are going to obtain from the moon to help us in reaching conclusions about the formation of the earth and the entire solar system.

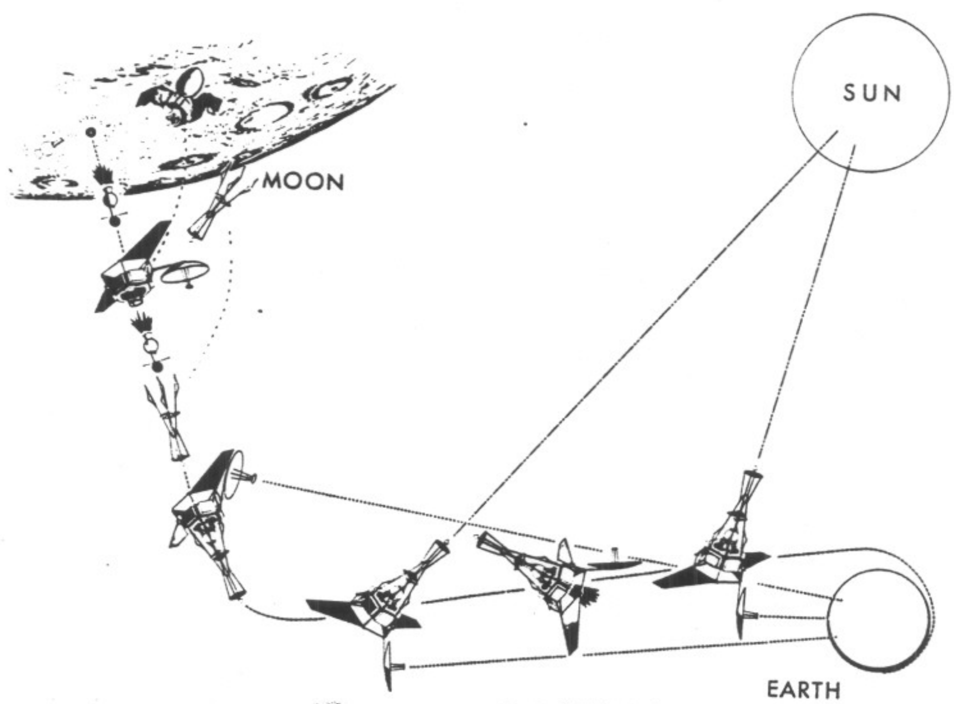
The time has now arrived to start filling in some of the gaps and holes in our knowledge.

We are now faced not with the dreams but with the realities of the space business. We must place in the sequence of potential achievement the missions which will yield the most benefit for the least expenditure of money, time, and talent. We must produce realistic designs within the current state of the art and press advanced development in the appropriate areas so that the new state of the art will be directly applicable to our needs. With infinite patience and care we must fabricate and test our designs and carry out our field operations so that we maximize the reliability of these inherently complex items.

The basic facts of space exploration also provide us with new constraints and requirements concerning the practical approaches which we must use. We are faced with extremely long ranges over which we would like to transmit great quantities of information. We are faced with extreme vacuums. We are faced with types and quantities of radiation about which we are just beginning to learn. For the exploration of the moon and the planets, we are faced with the very new and difficult problem of providing the best possible sterilization of our equipment so that we do not start any life cultures on these bodies which we later would observe and conclude were endemic to that body.

Let me review for you the lunar and planetary spacecraft work which is actually in the design and fabrication stages. At the same time, let me indicate how this work repre- (CONTINUED ON PAGE 91)

The author, left, and Donal B. Duncan, general manager of space technology operations for Aeronutronic, show models of the initial Ranger spacecraft and the lunar-impact capsule it would deliver. Aeronutronic, a Div. of Ford Motor Co., is developing the 300-lb capsule (shown 1/4 scale) for NASA. Notice spherical retrorocket on capsule.



Ranger Midcourse and Terminal Maneuver

Shape of Tomorrow

(CONTINUED FROM PAGE 25)

sents one of the many steps which we must take in the over-all evolution of spacecraft development.

To date, the U.S. lunar and interplanetary spacecraft have utilized the elementary technique of spinning the payload in order to achieve a degree of stabilization. However, experiments of the future call for full attitude stabilization. We must have long-life, continuously operating spacecraft, complete with all of the pertinent elements. These spacecraft must have their own propulsion and guidance systems for midcourse and terminal maneuvers. They must also have internal devices to generate power either from solar cells or from nuclear sources. They must have continuous three-axis stabilization either through some sort of reaction jets or momentum-wheel exchangers. They must have preprogrammed information stored away as a basis for future action. They must carry logic circuits to perform particular missions which vary in accordance with the conditions. They must have communication systems utilizing the available power and bandwidth in the optimum, and thus highly directional antennas in order to increase the gain and consequently to increase the information which can be transmitted. And the new spacecraft must carry payloads of scientific or engineering experiments to increase our knowledge of the space about us and far away from us and to help define the problems these environments present.

At the present time, the Jet Propulsion Laboratory is concluding the design phase of the Ranger spacecraft. This spacecraft has a first set of the complete elements just enumerated. The actual flight version, shown on page 24, will be about 12 ft long and will weigh 700 to 800 lb. It will be launched by an Atlas Agena-B rocket.

The first Ranger flights are now scheduled for next year. The initial effort will concentrate on perfecting the various engineering elements of the system, and will involve attempts to achieve long operating life. At the same time, they will carry some scientific equipment geared to obtaining a comprehensive survey of the radiation particles in space and the factors which influence them—a rubidium-vapor magnetometer, an ionization chamber, solar-corpuscular-radiation detectors pointed in different directions and with different sensitivities, a Lyman-α telescope which looks back at earth to examine the nature of the hydrogen clouds surrounding it, etc.

In subsequent flights, this same basic spacecraft will be used as a bus to carry a capsule to the moon. Just recently, JPL let a contract with the Aeronutronic Div. of Ford Motor Co. to develop the survival capsule to ride on this bus. The scientific package on the front of the Ranger spacecraft will be removed and the capsule will be mounted on the hexagonal surface. A midcourse propulsion system will be added to the main vehicle, or bus, to provide a maneuver part way out on the trajectory to insure a lunar impact of the capsule. As the bus approaches the moon about 66 hr after the launch, it will orient itself so that a TV camera will take a series of pictures with improving resolution as the bus approaches the moon. The bus will also carry a gamma-ray spectrograph which will allow us to obtain a preliminary analysis of some of the fundamental elements on the moon and thus help to determine what type of material it is made of. About 20 miles above the surface of the moon, the capsule will separate from the spacecraft bus and, with the aid of a solid-propellant retrorocket, slow down the approach of the capsule from about 6500 to 200 mph, as indicated in the sketch on page 25.

Inside the Capsule

The capsule proper, containing the instrumentation, will be protected by crushable structures to withstand an impact of 1000 g. Within the capsule will be an accelerometer to measure landing impact, a thermometer to measure the temperatures on the surface of the moon, and a seismometer to measure moonquakes and meteor impacts. It will also contain a power supply, transmitter, and radiating antenna for a total weight of about 50 lb.

The Atlas Agena-B that will launch Ranger was optimized to provide earth-satellite capabilities, and is usable at lunar distances. However, it cannot carry significant loads up to the velocities necessary to go to either Venus or Mars. Therefore we are looking forward in late 1962 to utilizing the Atlas-Centaur configuration to send spacecraft to Venus and Mars. These spacecraft will use the same basic elements that have been developed in the Ranger tests just discussed.

When this spacecraft makes a trip past Venus, it will carry equipment to try to learn more about the atmosphere of Venus and to try to penetrate through that atmosphere to learn more about the planet itself. Typical of the instruments which will be carried on board are the following: Ultraviolet spectrograph, a light-polarization detector, a passive (temperature) radar, an active radar, a magnetometer, a solar-corpuscular-radiation analyzer, a cosmic-ray detector, and an infrared scanner.

When the spacecraft makes a trip past Mars, in place of the passive and active radar it probably will carry equipment to obtain a detailed infrared picture mosaic. The picture will be broken up into a number of reasonably small squares and the infrared response within each square will be indicated. Thus, it should be possible to determine something about the forms of plant life which might be on Mars. This Mars spacecraft will probably also take a photograph of Mars from a few thousand miles away to increase our knowledge of the planet in the visual spectrum.

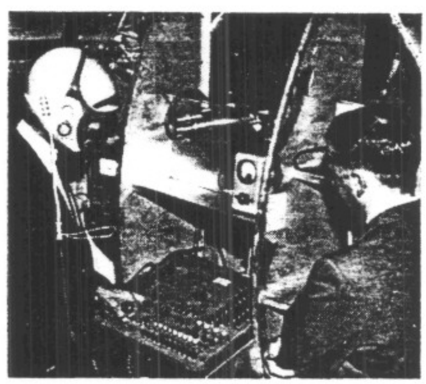
The Atlas-Centaur combination provides us with a capability of lifting approximately a ton of equipment to the vicinity of the moon. By appropriate use of retrorockets and capsules, this means that we can have lunar orbiters with several hundred pounds of instruments or we can soft-land about 100 lb on the lunar surface.

The year 1960 will see our national effort move from the dream to the design stage for these lunar soft-landers and orbiters.

In addition, effective utilization of the weight-lifting capability of the Saturn, discussed on page 26, is providing many interesting challenges in terms of basic mission decisions, corresponding system designs, reliability, economics, and many other factors.

Although these projects may lack "science-fiction appeal," consider how they would have sounded a scant 10 years ago. ◆◆

Just the Prelude



NASA Astronaut M. Scott Carpenter, in helmet, talks over a mockup of the Project Mercury communication system in the Collins Radio labs at Cedar Rapids, Iowa, which he recently visited on a familiarization tour. Contractor for the complete communications system, Collins has delivered five of the twenty on order to McDonnell Aircraft.