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A SUGGESTION FOR EXTENSION OF THE NASA RANGER PROJECT IN SUPPORT OF MANNED SPACE FLIGHT

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PREFACE

This Memorandum argues informally that the Ranger project could be extended beyond its present termination date to the advantage of the Manned Space Flight Program. It offers program planners a course that might provide considerable return, both technical and scientific, and suggests that the additional costs incurred might be more than offset in terms of benefits to manned spaceflight as well as unmanned spaceflight projects.

The suggestion was developed as part of the Apollo Contingency Planning Study being performed for the Director of Advanced Manned Missions in the Office of Manned Space Flight at NASA Headquarters under Contract NASr-21(09).

SUMMARY

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Once Rangers 8 and 9 have been launched, this project, after three frustrating but rewarding years, will be terminated. It is suggested that a production version of this vehicle could continue to serve the programs for lunar exploration, both manned and unmanned, as an operational tool as well as provide valuable scientific information about the moon. To discontinue the series is to lose the opportunity of providing relatively inexpensive support for the far more expensive Surveyor and Apollo projects. AUTHOR

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I. INTRODUCTION

On 23 August 1961 the first of a new series of lunar spacecraft was launched. The system achieved earth orbit, failed to re-ignite, and decayed one week later. Thus began the Ranger project, the successor to the unsuccessful Pioneer flybys of 1958--59 and the Atlas--Able orbiters of 1959--60. Three years would pass before a Ranger spacecraft would succeed in its primary mission of obtaining scientific information about the moon. Those three years were filled with much frustration, considerable pressure, spacecraft redesign, management changes, a NASA board of inquiry in 1962, a NASA failure review board in 1964, and a congressional investigation held by the Subcommittee on NASA Oversight of the Committee on Science and Astronautics of the U.S. House of Representatives. The document subsequently issued by the subcommittee describes these three years in detail.(1)

On 28 July 1964 the seventh Ranger spacecraft was launched. Some 66 hours later it crashed into the moon in a region of Mare Nubium east of the crater Guericke and west of the mountain range Riphaeus.(2) Before crashing, Ranger 7 transmitted back to the earth pictures of lunar craters as small as three feet in diameter and one foot deep. Although these pictures leave many questions unanswered, both scientifically and technically the flight was far more successful than could have been expected.

What can we expect of the Ranger project in the future?

Just two Ranger flights remain to be launched; there are no plans at this time to extend the series beyond these two. Instead, interest will center on a new series of spacecraft for lunar exploration. The Centaur-based Surveyor, under development for several years, will be soft-landed on the moon to sample the lunar soil, test its strength, and view the surrounding lunar landscape. The Atlas--Centaur launch-vehicle propulsion system is expected to play a major role in the exploration of the moon and planets. It was initiated in 1958 before NASA was formed; the first launch was scheduled for the middle of 1961.[(3)] To date the Centaur has been tested three times. It failed in May 1962, succeeded in November 1963, and failed again in June 1964.

There is no question that the solution to many of the lunar problems will require the landing of a spacecraft on the moon, but is it reasonable for such a system, yet untried, to totally replace the fully developed and tested Ranger? If the Ranger had no further usefulness, either scientifically or to the Manned Space Flight Program, closing out the project would be logical. Certainly this is not the case. The controversy concerning the structure of the lunar surface[(4)] and the origin of craters[(5)] continues.

II. RANGER 7 IMPACT SITE

With just two Ranger flights remaining, there will be strong pressures, probably with justification, to use them to examine types of lunar terrain different from the environs of Mare Nubium. Ranger 7 crashed in a region confused by the ray systems from the craters Copernicus and Tycho. Other maria might be more typical of the lunar lowlands. Yet to be examined are the highlands and the interiors of large craters. With such a wealth of possibilities available, there is little likelihood that either Ranger 8 or 9 will follow Ranger 7 to Mare Nubium for a second look. This is just what some future Ranger should be programmed to do.

Close examination of photographs of the impact region before and after Ranger 7 possibly could determine the presence or absence of dust as a main constituent of the lunar surface. The size, shape, and appearance of a crater caused by an impacting object depends on the size and velocity vector of the object and the structure of the surface. In a loosely cemented dust surface of low density the resulting crater would be much larger than it would be if the surface were solid rock. The appearance of small secondary craters caused by the original impact also is dependent on the structure of the surface. Studies on the lunar surface,[6] lunar crater interpretation,[7] and impact mechanics[8] describe these effects in detail.

A mission to re-examine the Mare Nubium site appears to be within the capabilities of the Ranger system. NASA has announced that the Ranger 7 spacecraft hit the moon within six miles of the planned impact site and arrived within 19 seconds of its planned arrival time. Although the capability existed, no terminal maneuver was employed. It is difficult to estimate the size of the crater that was formed by the impact. From energy requirement considerations, Baldwin has estimated[9] that a nickel-iron meteorite four feet in diameter striking a lunar surface of sand, clay, or gravel at ten miles per second would produce a crater over 500 feet in diameter. Ranger, though five feet in diameter at its base, weighed only 800 pounds and hit the moon at less than two miles per second. It can be estimated that the resulting crater probably is of the order of 25 feet in diameter. The distance above the moon's surface at which the Ranger crater could be observed is dependent, of course, on the actual size of that crater and the above mentioned guidance accuracy. NASA has stated that the final picture obtained by Ranger at an altitude of 1600 feet showed objects as small as ten inches. The field of view at this low altitude was somewhat larger than one square mile. The field of view of the smaller of the two full-scan cameras at 12 miles altitude was 16 square miles. Craters as small as 45 feet in diameter were detected. Within these limitations, a mission to re-examine the Ranger 7 impact site seems feasible.

There is no doubt that the question concerning the amount of dust on the lunar surface will be resolved once a Surveyor spacecraft has been landed successfully on the moon or a lunar orbiter has been properly placed around the moon. But when will this be? Optimistically we can expect the first Surveyor in late 1966; the first lunar orbiter is scheduled for the middle of the same year. Since both spacecraft are new systems, it is difficult to predict when they will succeed. The Apollo project needs the answer now. If the Ranger project were extended, perhaps Ranger 9 could be reprogrammed to obtain it.

III. THE EYES OF THE SURVEYOR AND APOLLO PROJECTS

The re-examination of the impact site of Ranger 7 -- and possibly those of Lunik 2 and Ranger 6 -- probably would not alone justify an extension of the Ranger series. It is proposed, however, that an active series of Rangers could be a valuable operational tool for both the manned and unmanned lunar spaceflight programs for the remainder of this decade and possibly into the next. During this period, Surveyor and Apollo spacecraft will be landing on the moon. If our experience with other major spacecraft is any indication, not all of these Surveyors and Apollos will be successful. It may be imperative to be able to determine what happened to a specific spacecraft after it landed. An operational Ranger with a guidance system somewhat improved (e.g. being able to perform a second mid-course maneuver) and a good probability for a successful mission would be able to visit the lunar site in question and transmit pictures of what it sees. It would, in effect, become a flying astronomical telescope, a probing set of eyes.

Certainly the mission just described would be expensive, but even an estimated cost of 20 million dollars per flight for a production Ranger would be considerably less than that of, for instance, an untried Centaur-launched Surveyor or two. Large sums have been invested in the Surveyor and its launch vehicle. As of 31 December 1963 the total amount of funds authorized for Centaur development and procurement is greater than $750 million.[10] The estimated cost of the scheduled seven Surveyors is approximately $300 million.[11] This investment is worthy of protection.

An operational lunar orbiter might be able to perform a similar mission. The cost of this project is competitive, an estimated $100 million for five flight vehicles, and the launch vehicle, the Atlas-Agena, is the same one used by Ranger. Several operational constraints imposed by the orbital mission, however, lessen its usefulness as an operational vehicle. The launch, injection, and translunar trajectory are similar to those employed by Ranger. The spacecraft will be placed first in a 950 km lunar orbit and then deboosted into an elliptical orbit with a lunar perigee of 46 km. If the lowest point of the orbit is over the target area, the higher-resolution lens system of the two on board is expected to detect objects as small as one meter. Spacecraft data collection and transmission to the earth cannot be done simultaneously. Only during the 46 minutes per orbit when the sun and the earth are mutually visible to the spacecraft can information be transmitted. Under these conditions it will require ten days to transmit all the pictures the system is capable of recording. The confidence in the operation's success must be tempered by demonstrated spacecraft reliability.

Ranger has been flight tested seven times to date. The first lunar orbiter spacecraft will be tested a year and a half from now. Since the orbiting spacecraft system must demonstrate the ability to change its orbit and transmit its data over a ten-day period within the constraints of the imposed geometry, it would appear that the Ranger has a definite advantage over the orbiter as an operational vehicle for the manned and unmanned lunar spaceflight programs.

Since future missions and human safety may be involved, utilizing the Ranger might be a relatively inexpensive way to obtain answers to critical questions involving more expensive spacecraft systems.

IV. POSSIBLE AUXILIARY BENEFITS

The potential scientific usefulness of the Ranger spacecraft will not be ended once the next two have been launched. If both are successful, we will have, at most, sets of pictures of three regions on the moon. Even if one dared assume that a good deal of the lunar terrain will be similar to one of these regions, three points in an area nearly as large as the combined continents of North and South America is hardly an overwhelming amount of data. Rangers could be used to examine other interesting areas including, perhaps, regions on the unknown side of the moon. Of course, the lunar resolution obtained with a Ranger programmed to view the far side of the moon would not necessarily be as fine as that obtained with Ranger 7, for the pictures would have to be transmitted before the earth became obscured by the moon. The lunar orbiter with its planned one-meter resolution could obtain better pictures than Ranger only of specific regions on the far side of the moon, provided the low point of its orbit can be placed over those regions. Such an orbit could degrade the primary mission objectives of the system. Apollo and post-Apollo missions are several years removed in time and cannot be considered competitive.

The primary mission of the lunar orbiter project is to obtain photographic information in support of Surveyor landing-site selection and Apollo landing-site certification. Over a period of weeks it will obtain pictures of sufficient resolution to permit the mapping of pertinent lunar areas. Ranger photographs of specific types of lunar topography at an ultimate resolution of four times that of the orbiter would be useful in the photo-interpretation of the pictures obtained from lunar orbit.

The availability of Ranger spacecraft also would permit the examination of the earth from various distances. This mission could be attempted now, but no project leader with just two flights remaining would dare attempt it. In the years to come it is hoped that more and more probes will be launched to the planets Venus and Mars. Examining the earth as a planet under similar conditions, ideally with similar equipment, would provide valuable experience for the interpretation of data transmitted from another planet. No plans exist for such a project.

V. SUGGESTIONS AND CONCLUSIONS

With the launching of Rangers 8 and 9, scheduled for early 1965, this series of lunar spacecraft, under development now for three years, will be terminated. It is suggested that NASA consider the extension of this series of spacecraft beyond its present termination date. The Ranger could be programmed to perform the following worthwhile missions:

1. Examine the impact sites of Ranger 7 and earlier craft. The successful landing of an Apollo spacecraft on the surface of the moon depends, among other things, on the presence and the amount of dust on the surface.

2. Perform operational postevaluations of Surveyor and Apollo landings. The resulting benefits to these projects alone might more than offset the cost of the additional Rangers.

3. Examine lunar areas above and beyond the maximum of three that might be observed with the present series. High-resolution photographs of various types of lunar topography would be helpful in advancing our knowledge of the moon and interpreting photographs obtained from a spacecraft orbiting the moon.

4. Observe the earth as a planet. We know nothing of how the earth appears from distances comparable to the expected miss distances of the Mariner series of space probes to Venus and Mars.

It is a natural tendency for program planners to strive for accomplishments each greater than the last. In this manner progress is made. From time to time, however, it might be wise to consider what can be gained with an existing set of equipment. It is suggested that an extension of the Ranger spacecraft series would aid and assist the Surveyor and Apollo projects, provide valuable scientific information, and be well worth the cost.

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