OPTIONAL FORM NO. 10

UNITED STATES GOVERNMENT

Memorandum

TO : M - Mr. Holmes

DATE: November 6, 1961

FROM : ML - Mr. Rosen

SUBJECT: Large Launch Vehicle Program

Pursuant to discussions with you and Dr. Seamans, I have organized a working group consisting of members of my staff, augmented by representation from MSFC and the Office of Spacecraft and Flight, to examine the reports of several committees and on the basis of these reports, and our judgment and analysis, to recommend to you a large launch vehicle program which will:

1. Meet the requirements of manned space flight, and
2. Have broad and continuing national utility (for other NASA and DOD missions)

Our principal background material will consist of the reports of the following groups:

1. The Large Launch Vehicle Planning Group (Golovin Committee)
2. The Fleming Committee
3. The Lundin Committee
4. The Heaton Committee
5. The Davis-Debus Committee

The following people are members of the working group:

<u>Launch Vehicles & Propulsion</u>

Mr. M. W. Rosen, Chairman
Mr. R. B. Canright
Mr. Eldon Hall
Mr. Elliott Mitchell
Mr. Norman Rafel
Mr. Melvyn Savage
Mr. A. O. Tischler

<u>Marshall Space Flight Center</u>

Mr. Wm. Mrazek
Mr. Hans Maus
Mr. James B. Bramlet

<u>Spacecraft & Flight</u>

Mr. John Disher

Our approach is to start out by having sub-groups make critical evaluations of some of the most important problems. Having done this, we will be in a better position to formulate a recommended program. Some of the subjects we are considering are:

1. An assessment of the problems involved in orbital rendezvous
2. An evaluation of intermediate vehicles (C-3, C-4, C-5 class)
3. An evaluation of NOVA class vehicles
4. An assessment of the future course of large solid rocket motor development
5. An evaluation of the utility of TITAN-III for NASA missions
6. An evaluation of the realism of the spacecraft development program (schedules, weights, performances)

Preliminary discussions within the group as to our mode of operation and the scope of our work have taken place this week. This memorandum is the result of these discussions. We have set as a target having in your hands a recommended program, and an evaluation of the more critical factors affecting it, by November 20.

I need your help in the following areas:

1. Immediate access to the report of, and supporting data used by, the Golovin Committee.

2. The opportunity of completing our work before further decisions are made in the areas we are examining. Should the need arise for a critical decision prior to November 20, we will be available at any time on or after November 13 to give you an oral briefing of our up-to-date findings.

Milton W. Rosen
Director, Launch Vehicles & Propulsion
Office of Manned Space Flight

Complete report in chron file

M - Mr. Holmes

November 20, 1961
ML(MWR:gbm)

ML - Mr. Rosen

Recommendations for NASA Manned Space Flight Vehicle Program

1. In accordance with my memorandum to you of November 6, I am presenting, for your consideration, a summary report prepared by the working group on vehicles for manned space flight. The members of the group were as stated in the November 6 memorandum, with the addition of Mr. David Hammock of the Space Task Group.

2. This report represents the distilled judgment of the group. No attempt was made to enforce or obtain unanimity. A small minority may differ with the wording of some of the recommendations. The general approach of the report, as a whole, is supported by the group, as a whole, and in this sense represents a consensus. Differences of opinion arose in three areas: rendezvous vs. direct flight, solids vs. liquids, and the nature of the intermediate vehicle. These differences are in the nature of emphasis rather than content. This situation is best illustrated by the tape recording made during the final session of the group.

3. The group had available the final recommendations of the Golovin Committee and preliminary drafts of several of the report chapters. We took the view that the Golovin Committee had opened doors to rooms which should be explored in order to formulate a program. Our report consists of a finer cut of the Golovin recommendations -- it is more specific with regard to the content and emphasis of a program. We believe such closer definition is required in order to arrive at a 1963 budget.

4. The program we are recommending to you is, in my opinion, the best we can offer at this time. It takes account not only of technical factors, but also of the realities of the budgetary and political situation. We are preparing a budget and schedule as an appendix to this document. I propose to have these in your hands by November 22. My gross estimate at this time is that the program recommended here can be funded by the Plan A budget ($4,233 million) recommended by Mr. Webb to the Director of the Budget. The Plan B ($3,699 million) budget would be inadequate. Should it develop that the Plan A budget is not obtainable, we are prepared to undertake a further condensation of the program to meet a lesser figure. It must be admitted, however, that such a step starts to eliminate some important alternative approaches.

5. Those of us who participated in this intensive two-week effort feel that our work has been worthwhile in clarifying in our minds the very important issues that are the subject of this report.

Original signed by
Milton W. Rosen

Milton W. Rosen
Director, Launch Vehicles & Propulsion

Attachment: as stated

REPORT OF COMBINED WORKING GROUP ON VEHICLES FOR MANNED SPACE FLIGHT

Recommendations

1. The United States should undertake a program to develop rendezvous capability on an urgent basis.

2. To exploit the possibility of accomplishing the first manned lunar landing by rendezvous, an intermediate vehicle with five F-1 engines in the first stage and four or five J-2 engines in the second stage and one J-2 in the third stage should be developed. The vehicle should be so designed that it can be modified to produce a three engine first stage, if rendezvous is difficult to achieve. The three engine vehicle provides a better match with a large number of NASA and DOD requirements and earlier flights in support of the manned lunar program.

3. The United States should place primary emphasis on the direct flight mode for achieving the first manned lunar landing. This mode gives greater assurance of accomplishment during this decade. In order to implement the direct flight mode, a NOVA vehicle consisting of an eight F-1 first stage, a four M-1 second stage, and a one J-2 third stage should be developed on a top priority basis.

4. Large solid rockets should not be considered as a requirement for manned lunar landing. Should these rockets be developed for other purposes, the manned space flight program should support a solid first stage development in order to provide a backup capability for NOVA.

5. Development of the one J-2 engine S-IVB stage should be started, aiming toward flight tests on a Saturn C-1 in late 1964. It should be used as the third stage of both C-5 and NOVA, and also as the escape stage in the single earth orbit rendezvous mode.

6. NASA has no present requirement for the TITAN III vehicle. Should the TITAN III be developed by the DOD, NASA should maintain continuous liaison with the DOD development to ascertain if the vehicle can be used for future NASA needs.

DISCUSSION

1. Rendezvous

The capability for rendezvous in space is essential to a variety of future space missions. These include crew rotation and resupply of orbiting laboratories and space stations, orbital assembly for future manned planetary missions, and rescue operations in orbit. For these reasons alone a vigorous high priority rendezvous development effort must be undertaken immediately.

The United States should undertake a program to develop rendezvous capability on an urgent basis.

Space rendezvous presents the possibility of accomplishing the initial manned lunar landing mission earlier than by other means and therefore should also be considered for that mission.

Several modes of rendezvous in space have been proposed for accomplishing the initial lunar landing mission. The favored modes are (1) a single rendezvous and docking in earth orbit, (2) a single rendezvous in lunar orbit by a lunar excursion vehicle which departs from a parent craft in lunar orbit, descends to the lunar surface and returns to the parent craft which remains in lunar orbit. The second alternative offers the possibility of mission accomplishment with only one earth launch of the same type launch vehicle of which two are required for the earth orbit rendezvous. It also offers the possibility of a smaller and simpler lunar landing vehicle for the initial landing attempt. However, the lunar orbit rendezvous operation entails appreciably greater human risk than does earth orbit rendezvous because a missed rendezvous at the moon is fatal whereas a missed earth rendezvous simply aborts the mission. The lunar rendezvous vehicle also lacks substantial radiation protection and lands only a minimal payload on the moon with limited staytime and scientific equipment.

After comparing the advantages and disadvantages of the two rendezvous modes it has been concluded that the preferred rendezvous mode is the single rendezvous in earth orbit.

It is imperative to recognize that rendezvous offers only a possibility of carrying out the initial landing more rapidly than by other means. Because we will not have our first experimental indications of the difficulty of performing rendezvous until 1964 we will not until that time have a firm basis for estimating and scheduling the time required to develop high reliability space rendezvous, docking, and fuel transfer operations.

The Heaton Committee investigated the docking method for earth orbit rendezvous and concluded that the launch vehicle should have sufficient capability so that only one rendezvous would be required. About four rendezvous (5 vehicles) are required with the C-3. Hence, emphasis shifted from the C-3 to the C-4 vehicle. At that time it was believed that adequate capability could be obtained with two C-4 vehicles. A more detailed investigation indicates that the C-4, when designed and built with sufficient structural and flight margins for high confidence, is inadequate with only one rendezvous for the desired allowable spacecraft weight. The C-5 has adequate margin with one rendezvous.

If several rendezvous in earth orbit are shown to be entirely feasible, the use of a C-3 class vehicle would be suitable with a fueling type of operation but not with a docking type because of the structural considerations of combining five vehicles. Two rendezvous maneuvers with three C-4 vehicles would be suitable with either docking or fueling. The C-5 vehicle is capable of performing the single earth orbit rendezvous mode without refueling and is also capable of performing the lunar orbit rendezvous mode as described above.

> To exploit the possibility of accomplishing the first manned lunar landing by rendezvous, an intermediate vehicle with five F-1 engines in the first stage and four or five J-2 engines in the second stage and one J-2 in the third stage should be developed. The vehicle should be so designed that it can be modified to produce a three engine first stage, if rendezvous is difficult to achieve. The three engine vehicle provides a better match with a large number of NASA and DOD requirements and earlier flights in support of the manned lunar program.

The working group examined rendezvous more intensively than any other subject in an attempt to understand the technical and operational problems involved. This effort led to the conclusion that the development of rendezvous, and its use for manned lunar landing, cannot be scheduled with any reasonable degree of assurance. We urge development of rendezvous in its own right and so that a better assessment of its use for manned lunar landing can be made in the next year or two.

2. Direct Flight

In order to inject the Apollo spacecraft into a lunar trajectory without recourse to orbital assembly or refueling, a launch vehicle with capability equivalent to that provided by an 8 F-1 engine first stage is required. Such a launch vehicle presents no different order of technical problems than does a 5 F-1 engine first stage. Larger facilities are required for fabrication and test, and the first unit will take more man hours to build and test, but the problems are the same.

The group examined versions of NOVA suggested by the Golovin Committee. The chosen configuration places emphasis on achieving early manned lunar landing by direct flight, with sufficient margin for both spacecraft and vehicle contingencies, and in addition, offers potential for missions beyond manned lunar landing. This configuration consists of a first stage with 8 F-1 engines, a second stage with (4-1)* M-1 engines and an S-IVB third stage, the same as the third stage of the C-5 and the second stage of the C-1B Saturn. This version has growth potential and also offers the advantage that it could utilize the four 240-inch solid first stage if it were to be developed.

We have examined the feasibility of producing this NOVA vehicle and have concluded that it can be scheduled with a reasonable degree of assurance. An optimistic schedule would provide an earliest capability in late 1966; a pessimistic schedule would provide an earliest lunar landing capability in 1968. It appears reasonable to plan on the availability of this type of NOVA vehicle in 1967 for the achievement of manned lunar landing.

*Four engines with one engine out capability

The United States should place primary emphasis on the direct flight mode for achieving the first manned lunar landing. This mode gives greater assurance of accomplishment during this decade. In order to implement the direct flight mode, a NOVA vehicle consisting of an eight F-1 first stage, a four M-1 second stage, and a one J-2 third stage should be developed on a top priority basis.

3. Solid Rockets

The group examined the prospects for developing large solid rockets for first stages of the intermediate and NOVA vehicles. In particular, we examined the 156-inch segmented motor and the 240-inch monolithic motor. The group concluded that both of these versions could be developed, and that the elapsed time between now and the first motor test could be scheduled with reasonable assurance. There was considerable uncertainty as to the number of motor tests required to solve technical problems and to achieve a reasonable degree of reliability, to the number of stage tests which may be required and to the number of flight tests. On the other hand, success of the F-1 and J-2 engines must be assured if the program proposed here is to be undertaken at all. Since these engines must be developed to a high degree of reliability for the intermediate vehicle, it seems only sensible to use them in NOVA. These considerations led to the conclusion that the present program for manned lunar landing should be based on liquid propulsion, and that solid rockets should serve as a backup only.

Large solid rockets should not be considered as a requirement for manned lunar landing. Should these rockets be developed for other purposes, the manned space flight program should support a solid first stage development in order to provide a backup capability for NOVA.

4. Saturn Class Vehicles

As recommended by the Golovin Committee, development of Saturn C-1 should be continued to provide an early capability for orbital tests of Apollo.

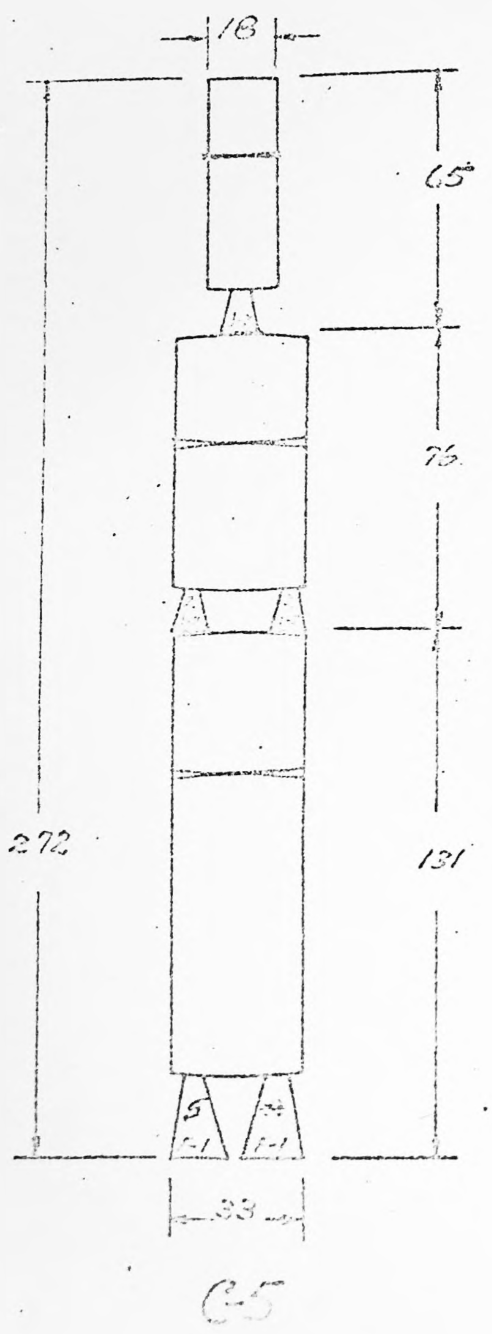
A one J-2 engine top stage can serve the C-1, C-5, and NOVA. It also serves, with modification, as the escape tanker in the single earth orbit rendezvous operation. In other words, in any mode of operation recommended here, when the Apollo spacecraft is sent from orbit to escape, it uses the S-IVB. We have examined the development schedules of the S-IV and the S-IVB and have concluded that the S-IV leads the S-IVB by at least one year. Substitution of the S-IVB at this time would result in a year's delay in first flights of the Apollo spacecraft on Saturn. Since the Apollo orbital flights are to start with the Saturn C-1, using the S-IV, it may be prudent and desirable to continue this version of Saturn C-1 for all of the Apollo orbital tests. In this case, we recommend that two or three Saturn S-1's be devoted to vehicle tests of the S-IVB stage at an early date, in order to qualify the S-IVB for its future use on the C-5 and NOVA.

Development of the S-IVB stage should be started, aiming toward flight tests on a Saturn S-1 in late 1964, and use as the third stage of both C-5 and NOVA, and also as the escape stage in the single earth orbit rendezvous mode.

The group examined information available on the TITAN III, its performance, future availability and developmental problems.

The TITAN III and the Saturn C-1 are competitive in orbital performance. The TITAN III, alone, has some escape capability which is enhanced by addition of a fourth stage. The Saturn C-1 has an appreciable escape capability through the addition of a third stage. One major difference is that the TITAN III core has a 10-foot diameter and only with difficulty could carry large diameter payloads. The Saturn C-1, on the other hand, has an 18-foot diameter and could be provided with a third stage of similar diameter, for example, the following combination /S-I - S-IVB - S-IV/. Escape payloads presently planned by NASA for Centaur utilize the full 10-foot diameter of that vehicle. Future escape payloads, requiring greater launch vehicle capability, fall in the diameter class of 12 to 18 feet. Launch vehicle requirements for these payloads can be met by the Saturn C-1.

NASA has no present requirement for the TITAN III vehicle. Should the TITAN III be developed by the DOD, NASA should maintain continuous liaison with the DOD development to ascertain if the vehicle can be used for future NASA needs.



COMPARISON OF BULK
SIZE OF C-5
AND NOVA VEHICLES