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6/4/65
1:00 p.m.



EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE
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EXECUTIVE SECRETARY

June 4, 1965

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress. The Senate passed the FY 1966 NASA authorization of \$5.196 billion June 2 by a vote of 79 to 4. An amendment to limit NASA's power to grant patent waivers to contractors was defeated.
2. Gemini. The U. S. second two-man spacecraft was successfully launched from Cape Kennedy at 11:16 A. M. EST, June 4 into an orbit with 179 miles apogee and 101 perigee. Astronaut White set a new record for extra-vehicular activity as he maneuvered himself about outside the spacecraft for a 23-minute period over a distance of 6500 miles. The plan to rendezvous with the spent second stage of the Titan II launch vehicle failed because of the rapidly decaying orbit of the second stage and the limited fuel supply for such maneuvers aboard the Gemini. The spacecraft is scheduled to return June 7 after 62 orbits and four days in space.
3. Other Launches
 - a. The third IMP satellite (designed to measure magnetic fields, cosmic rays, and solar winds) was launched May 29 by NASA into a highly eccentric earth orbit reaching two-thirds of the way to the moon.
 - b. The Department of Defense launched a military satellite into a polar orbit May 27 and on the same date had a failure.
4. Nuclear Rocket. The Nerva, a nuclear reactor for space use, was successfully ground tested for the third time May 28. The test lasted 43 minutes.
5. Lunar Drilling. NASA announced that astronauts on post-Apollo lunar missions would drill some 100 feet into the moon's surface for geophysical measurements. The core drilling unit would weigh less than 200 pounds.
6. Project Fire. The payload shaped like the Apollo command capsule which was launched into a reentry trajectory from Cape Kennedy May 22 reached a speed of 25,400 mph. The reentry package and data-gathering equipment all performed well.

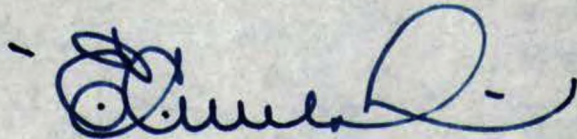
7. Tropical Storm Coverage. A tropical storm which hit East Pakistan May 31 was tracked by Tiros satellites from May 25, and advance warnings were sent to the affected areas.

8. TV Coverage of Gemini. East Germany, Czechoslovakia, and Poland joined with Western European countries to contract with the West European television network for coverage of Gemini-4 via the Communication Satellite Corporation's Early Bird satellite.

9. Foreign Eclipse Experiments. U. S. and foreign scientists were aboard a NASA jet aircraft observing the solar eclipse of May 30, 1965 in the South Pacific. Preliminary reports indicate the experiments were highly successful.

10. Space Payload Success Box Score
(June 4, 1965)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth Orbit	20	41	10	20
Escape	1	2	1	1



E. C. Welsh

Friday, June 4
Time: 11:45



22
16

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE

05
F611-4

EXECUTIVE SECRETARY

May 28, 1965

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress

a. Senate floor consideration of the NASA Authorization has been postponed until June 2 because of lack of agreement within the Committee over possible amendments affecting NASA patent policy.

b. The Senate passed the Atomic Energy Commission's FY 1966 Authorization May 24. The authorization cut AEC's \$22 million request for the SNAP 50 nuclear power project by \$10 million, as did the House on May 20.

2. Launches

a. A Project Fire payload, shaped like the Apollo command capsule, was launched from Cape Kennedy May 22. It successfully reentered the atmosphere at the speed which the Apollo vehicle will reenter after its return from the moon.

b. The ninth straight successful test launch of the 1.5 million pound thrust Saturn I took place at Cape Kennedy on May 25. The payload, a Pegasus micrometeoroid detection satellite, unfolded its 96 feet long wing spread in space and is operating effectively.

c. The Soviet Union May 25 launched Cosmos 67 into an orbit inclining from the Equator by 52 degrees. This type of payload is usually recovered in about eight days.

3. Saturn V. The seven and a half million pound booster, destined to be the first stage of the launch vehicle which will send Apollo to the moon, was static test-fired successfully for the third time May 20. The test was three months ahead of schedule.

4. Concorde SST. The British and French companies building the Concorde SST have announced they plan to increase the length of the plane so that it will accommodate more than 130 passengers. The announcement stated that the design change would not delay the 1971 target date when the plane is scheduled to go into commercial service.

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5. U. S. -USSR Cooperation. The Soviet Union informed U. S. representatives attending the COSPAR Meeting at Mar del Plata, Argentina, that US-USSR cooperation could not develop until more progress has been made on disarmament. There is still some possibility of negotiation next September during the meeting of the UN Outer Space Committee.

6. Weather Satellites. Tiros IX discovered tropical storm Amy in the Western Pacific May 21 and continued to track it until May 26 as it traveled from the Philippines to Southern Japan. Advance warnings were sent to the Philippines, Okinawa, Guam, Formosa, and Japan within an hour and a half after sighting.

7. Mariner IV. The U. S. Mars-bound spacecraft will have attained a distance of one astronomical unit or 93 million miles from earth by May 29. Mariner is continuing to transmit scientific and engineering data from deep space and sets new space long distance communications records with each transmission.

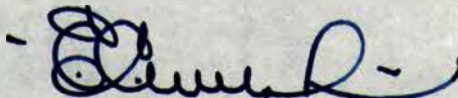
8. Pending Launches

a. A Gemini spacecraft is scheduled to be launched on its four-day, 62-orbit mission June 3. A number of experiments are expected to be carried out. Among them, Astronaut White is scheduled to move about outside the spacecraft during the second orbit.

b. The third IMP satellite (designed to measure magnetic fields, cosmic rays, and solar winds) is scheduled for May 29.

9. Space Payload Success Box Score
(May 28)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth Orbit	19	37	10	20
Escape	1	2	1	1


E. C. Welsh

Friday, May 28
Time: 11:15

EXECUTIVE

ME 3/5*

OS

PR 19

LG / St. Louis

STRAIGHT WIRE May 26, 1965

Mr. David S. Lewis^X
Chairman - ~~X~~ Space Symposium
Chase-Park Plaza Hotel
St. Louis Missouri

IT IS FITTING THAT ST. LOUIS,

IT IS FITTING THAT ST. LOUIS, WHERE THE SPACECRAFT FOR PROJECT GEMINI ARE BEING FABRICATED SHOULD HOLD A SPACE SYMPOSIUM AS PART OF ITS BICENTENNIAL CELEBRATION. THIS SYMPOSIUM ALSO CONSTITUTES THE MAJOR ACTIVITY IN THE FIFTH NATIONAL CONFERENCE ON THE PEACEFUL USES OF SPACE. THIS IS A SIGNIFICANT DEMONSTRATION OF THE STRONG, CONTINUING INTEREST THE AMERICAN PEOPLE HAVE IN THEIR SPACE PROGRAM AND OF THEIR AWARENESS OF ITS IMPORTANCE TO THE UNITED STATES AND FREE MEN EVERYWHERE. YOU ARE TO BE CONGRATULATED ON BRINGING TOGETHER SUCH AN ARRAY OF DISTINGUISHED AUTHORITIES ON ALL PHASES OF SPACE SCIENCE AND TECHNOLOGY.

EXTEND

I WISH TO ~~EXTEND~~ MY BEST WISHES TO THOSE WHO ARRANGED THE SYMPOSIUM AND TO THOSE WHO PARTICIPATED IN IT. I AM SURE THAT IT WILL BRING ABOUT GREATER UNDERSTANDING OF OUR NATIONAL SPACE PROGRAM, PERHAPS THE MOST PROMISING PEACE TIME VENTURE THIS COUNTRY HAS EVER UNDERTAKEN.

LYNDON B. JOHNSON

LBJ:FLH:mb

CC: Mr. Holborn
Central Files
PR Unit *sent*
Mr. Reedy *sent*

RECEIVED
MAY 27 1965
CENTRAL FILES

41.
i. Anderson
EXECUTIVE (3)
LE/OS
OS
BE6
1611-9

Saturday, May 22, 1965
9:15 AM

MEMORANDUM FOR

THE PRESIDENT

Following your suggestion, I worked closely with Senator Anderson on the patent clause in the NASA Authorization bill, and I promised him I would advise you of the outcome.

The clause proposed by Senator Anderson is not fully in accord with the October 1963 Patent Policy Statement but represents the most liberal clause he feels he can get by Senator Long. The clause is well drafted and workable for NASA. Senator Anderson and I both view it as an interim matter pending resolution of the principles involved in the course of hearings on the general patent legislation. Consequently, I have informed Senator Anderson that I will raise no further objections to the clause as written. There is likely to be some difference between the Senate and House versions which may still require another round of conferences.

Donald F. Hornig

DFH/eac

cc: Mr. O'Brien
Mr. Manatos ✓



EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

25 (31)
EXECUTIVE
05
FC11-X

EXECUTIVE SECRETARY

May 21, 1965

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress. The AEC authorization, as reported out by the Joint Atomic Energy Committee, passed the House on May 20 by a vote of 350-1. This action reduces the space portion of the AEC authorization request to \$144.6 million, with a \$10 million cut in the SNAP 50 nuclear power project.

2. Launches

a. Two military satellites were placed into polar orbits from Vandenberg Air Force Base on May 18 and May 20.

b. The Apollo spacecraft's launch escape was tested May 19. The second stage of the Little Joe II launch vehicle failed and introduced violent motions into the total assemblage, forcing the rescue system to save the spacecraft earlier than planned.

3. Nuclear Space Activity

a. The first nuclear reactor in space (SNAP 10-A) which had worked perfectly for over six weeks in orbit, failed on May 15. Its three thousand year orbit lifetime insures no radiation danger.

b. A Nerva rocket was tested very successfully in Nevada on May 20. The test ran for 18 minutes of which 13 minutes was at full power.

4. Cybernetics. By using techniques and equipment developed in the aerospace science and technology program, a Yale University Medical School professor has been able to control the behavior of a bull by implanting electrodes in his brain.

5. Commercial Applications. A paint developed by NASA for space use shows great promise for a wide range of commercial applications. The paint does not crack, peel, chalk, flake or fade under temperature extremes ranging from 1800 degrees Fahrenheit to -320 degrees F.

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THE WHITE HOUSE
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1965 MAY 21 PM 3 14

MEMORANDUM FOR THE PRESIDENT

Subject: [Illegible]
Reference: [Illegible]
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Very truly yours,

[Illegible signature block]

[Illegible text block]

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6. Pending Launches

a. A Project Fire reentry test is scheduled for launch from Cape Kennedy late on May 21.

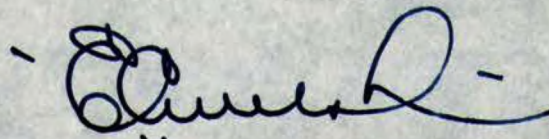
b. Launch of the next Saturn I vehicle (SA-8) with an improved Pegasus micrometeoroid detection satellite is scheduled for May 24.

c. A third in the Interplanetary Monitoring Platform (IMP) series of Explorer satellites is scheduled for launch from Cape Kennedy May 28. The IMP is designed to measure magnetic fields, cosmic rays, and the solar wind.

7. Argentine Agreement. NASA has signed an agreement with the Argentine Space Commission providing for launchings of meteorological sounding rockets from ranges in Argentina and the U. S. The agreement anticipates the establishment of an Inter-American Experimental Meteorological Network with launching stations in a chain running from Argentina to Canada.

8. Space Payload Success Box Score
(May 21)

	<u>USA</u>		<u>USSR</u>	
	1964	1965	1964	1965
Earth Orbit	19	35	10	19
Escape	1	2	1	1


E. C. Welsh

Friday, May 21
Time: 1:00 p. m.

SECRET

a. The project is currently scheduled for launch from Cape Kennedy late on May 27.

b. Launch of the next Saturn I vehicle (SA-3) with an improved booster is scheduled for May 28.

c. This is the latest in the Saturn I series (SA-1) series of launchers. The SA-1 is scheduled for launch from Cape Kennedy May 28. The SA-1 is designed to examine magnetic fields, cosmic rays, and the solar wind.

d. The SA-1 is a two-stage vehicle. The first stage is a solid rocket motor. The second stage is a liquid rocket motor. The SA-1 is designed to launch a payload of up to 10,000 pounds. The SA-1 is currently scheduled for launch from Cape Kennedy May 28.

Space Launch Vehicle (SLV) (SA-1)

SLV	SA-1	SA-2	SA-3
1964	1965	1966	1967
10	10	10	10
1	1	1	1

W. C. Welch

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MAY 24 1965
CENTRAL FILE

Time: 1:00 p.m.
Friday, May 27



8
EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE
05
FG11-4

Friday
May 14, 1965
11:45 a. m.

EXECUTIVE SECRETARY

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress

a. On May 11, the House passed the Independent Offices Appropriation Bill funding \$5.16 billion for NASA and \$525,000 for the Space Council. The NASA Appropriation compares with its request for \$5.26 billion and the House Authorization for \$5.183 billion. The Space Council amount was as requested.

b. Testimony on the Space Council budget was given May 12 before the Senate Appropriations Committee.

2. Launches

a. Luna 5, launched by the Soviet Union May 9, impacted the moon May 12. Announced as a test of a system capable of "soft" landing instrument packages on the lunar surface, the spacecraft's retro-rockets apparently did not fire and slow down the spacecraft. As a "soft lander," it was a failure.

b. On May 12, a Blue Scout Jr. launched the third of five cosmic radiation probes from Cape Kennedy to learn more about the distribution of energy in the inner radiation belt.

3. XB-70. A small piece of metal tore loose from the wing and ripped through three engines during the latest flight test of the XB-70. The accident, when the plane was flying at speeds reaching 1,680 miles per hour, forced a landing on Rogers Dry Lake. Repairs are expected by next Friday, and the next flight will attempt to reach Mach 2.8.

4. Communications satellites

a. The Federal Communications Commission May 12 established a policy allowing the Communications Satellite Corporation to operate three commercial communications satellite ground stations in the United States. The authorization has an expressed duration of two years.

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b. ABC has filed with FCC a notice of intention to employ a synchronous satellite to distribute network TV programs to all its affiliate stations throughout the U. S.

5. Future launches

a. Preparations are continuing for the second manned Gemini launch for June 3. The official date is still that of early third quarter.

b. The fourth test of the Apollo spacecraft's launch escape system is scheduled for the White Sands Missile Range May 19. A "boilerplate" version of the Apollo will be launched by a Little Joe II launch vehicle to an altitude of 112,000 feet, and then the launch escape system will be fired.

c. The Project Fire launch to test high speed reentry, twice postponed because of technical and weather difficulties, is now scheduled for May 20 at Cape Kennedy.

d. Launch of the next Saturn I vehicle (SA-8) with a Pegasus micrometeoroid detection payload aboard is scheduled for May 25 from Cape Kennedy.

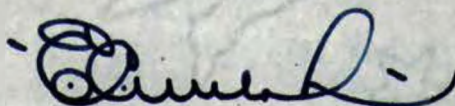
6. Japanese satellite. The Japanese have scheduled for testing this spring the first stage of a proposed three-stage launch vehicle designed to place 220 pound satellites into 625 mile circular orbits.

7. French satellite. The French National Space Center hopes to launch the first all-French satellite, the FR-1, aboard a U. S. Scout launch vehicle before the end of this calendar year.

8. Tiros. A major storm which hit East Pakistan on May 11 was observed by Tiros IX from May 9 through 11, and advance warnings were sent to affected areas in the Bay of Bengal and the Indian Ocean.

9. Space Payload Success Box Score
(May 14)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth Orbit	18	32	9	19
Escape	1	2	1	1



E. C. Welsh

...with the use of a ...
...to all ...
...the ...

3. Future launches

a. Preparations are continuing for the second ...
...The official date is still that of early third quarter.

b. The fourth test of the Apollo spacecraft's launch escape system is scheduled for the White Sands Missile Range ...
...the launch escape system will be ...
...an altitude of 11,000 feet, and then the launch escape system will be ...

c. The Project Five launch to test high speed recovery, twice postponed because of technical and weather difficulties, is now scheduled for May 28 at Cape Kennedy.

d. Launch of the next Saturn I vehicle (S-1C) with a ...
...is scheduled for May 28 from Cape Kennedy.

e. Japanese satellite. The Japanese have agreed to testing this ...
...the first stage of a proposed three-stage launch vehicle designed to place 300 pound satellites into a 100 mile circular orbit.

f. French satellite. The French National Space Center hopes to launch the first all-French satellite, the D-1, in 1965 ...
...the end of this calendar year.

g. Soviet. A major storm which hit the ...
...of Soviet ...
...were sent to affected areas in the ...

Space ...
(...)

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The White House
Washington

1965 MAY 14

Earth Orbit
Escape

EXECUTIVE

May 7, 1965

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OS

Dear Mr. Feldman:

I am delighted to have the inscribed copy of "The Reluctant Spacefarers," published by you and Frank X Gibney, and have noted with interest the preface it contains. Many thanks for providing this fine addition to my library.

With appreciation and best wishes,

Sincerely,

LYNDON B. JOHNSON
Carbons stamped in
Mr. Thomas' Office

Mr. George J. Feldman
640 Fifth Avenue
New York 19, New York

LBJ/T1/mpb

Gift

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MAY 13 1965
CENTRAL FILES

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EXECUTIVE

OS

FG 11-4

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON



EXECUTIVE SECRETARY

May 7, 1965

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress

a. House passed the NASA authorization bill by a vote of 388 to 11, which would authorize \$5.184 billions for that agency.

b. House Appropriations Committee reported out the Independent Offices Appropriations bill, which recommends to the House an appropriation of \$5.160 billions for NASA (a cut of \$100,000,000) and \$525,000 for the National Aeronautics and Space Council as requested.

2. Mars Probes

a. Soviet scientists have announced that their Zond II probe headed toward Mars has stopped transmitting. Further attempts will be made to activate the satellite.

b. The U. S. Mariner IV probe headed toward Mars is still functioning; and is sending back data from a distance of over 71 million miles.

3. Launches

a. The fourth launch test of Titan IIIA May 6 from Cape Kennedy placed a dummy payload and two small DOD payloads into orbit.

b. The USSR announced May 7 the launch of Cosmos 66. It was a low altitude satellite of the type normally recovered.

4. Soviet TV Satellite

a. The Soviet Union has announced that the orbit of their first communications satellite (Molniya I) has been adjusted to keep it positioned for longer periods over the Soviet Union. The adjustment is also expected to extend its daily useful coverage period from about 8 hours to 10 hours.

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b. In view of the success and location of the Soviets' first communications satellite (Molniya I), NASA has suggested to the Soviet Ministry of Communications that a two-way test be conducted, using their ground facilities and ours as well as their satellite. The suggestion was cabled May 3 and no response has been received to date.

5. Speed Records. The Air Force YF-12A set speed records this week at 1,688 mph on a circuit course, 1,642 over a closed course, and 2,062 mph over a straight course.

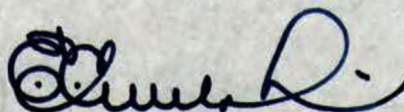
6. ESRO. The European Space Research Organization will purchase at least four U. S. Delta launch vehicles for the 1968-69 period, and two U. S. Scout vehicles in 1967. The launches will be U. S. conducted.

7. European Space Industry. European space firms hold 184 licenses from U. S. companies for a variety of devices, mostly in the electronics area, but also for rocket motors, inertial guidance, lasers and masers.

8. Early Bird. Communication test programs between the U. S. and Western Europe via ComSat's Early Bird satellite have proved successful. A significant upcoming event is a VE Day anniversary program on May 8.

9. Space Payload Success Box Score
(May 7)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth Orbit	18	32	9	18
Escape	1	2	1	0



E. C. Welsh

In view of the recent and location of the Soviet first
 communications satellite (Sputnik), which has been placed in the
 Soviet orbit at a distance of 200-300 miles from the earth, it is
 not surprising that the Soviet Union has also been successful in
 launching its own satellite, as well as other satellites. This
 launch was carried out on May 15, 1955, and was successful.

The Soviet Union has also been successful in launching its
 first satellite, which was placed in orbit on May 15, 1955, and
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Space Flight Research Report
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The White House
 Washington



EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE

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N.R.

FG11-4

EXECUTIVE SECRETARY

27
April 30, 1965

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress. The House Committee on Science and Astronautics has recommended a net cut of \$76.2 million in the NASA authorization request of \$5.26 billion. The total after the committee action is \$5.184 billion. They approved funding for the M-1 and the 260-inch rocket programs as well as the Snap 8. Money for these projects was not included in the NASA budget request. The committee has also proposed an amendment which would require NASA to employ geographic distribution standards in awarding research and development contracts.

2. Launchings

a. NASA's Beacon Explorer satellite, whose primary mission is to map the gravitational field of the earth, was launched April 29. It will also support a 36-nation cooperative survey of the electron content of the ionosphere. The satellite was launched by a Scout vehicle, which has had the remarkable recent reliability record of 12 successes during the last 13 launches.

b. The Soviet communication satellite launched April 23 was preceded by a previous attempt (Cosmos 41) during August 1964 which went into a very similar orbit and was unexplained at the time. The satellite reaches out to 24,500 miles at its highest point, which currently keeps it in good view of Soviet ground stations about eight hours each day for relay of television and message traffic.

c. The DOD placed in polar orbit on April 28 a military payload, using an Atlas Agena launch vehicle, and on April 29 another one using a Thor Agena launch vehicle.

3. Pending launches. On May 4, a heavily instrumented 200-pound Project Fire spacecraft will be launched from Cape Kennedy on a 5,000 mile ballistic trajectory to expand our scientific knowledge of reentry heat in support of Project Apollo. In an earlier flight of this

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MAY 3 1965

CENTRAL FILES

project, the spacecraft reached a speed of more than 25,000 miles per hour.

4. Engine tests

a. The ascent engine of the Lunar Excursion Module of the Apollo system underwent its first test on April 15.

b. On April 16, the five F-1 engines for the first stage of Saturn V were tested and developed 7.5 million pounds of thrust.

c. The April 23 test of the Nerva nuclear rocket ended after 8 minutes instead of 15 because of a spurious signal in the automatic test equipment. It is scheduled for another test on May 5.

d. On April 24, the five J-2 engines of Saturn V second stage were tested and developed 1 million pounds of thrust.

5. Quiet Sun Year. A total of 77 sounding rocket launches were made from the USNS Croatan as part of the U. S. participation in the International Quiet Sun Year.

6. Gemini. The second manned Gemini flight is tentatively scheduled for early June. It is expected to last four days, making 63 orbits and being recovered in the Atlantic. Astronauts McDivitt and White are expected to open the hatch of their spacecraft during the flight.

7. Tiros VII. This weather satellite, launched in June 1963, completed its 10,000th orbit this week, setting a new record for longevity of weather satellites. To date, this satellite has acquired nearly 100,000 useful weather photographs.

8. Solar activity. Intense sunspot activity in April affected the height and density of the earth's ionosphere so severely that the orbits of all low altitude satellites were perturbed. This is the first time this phenomenon was noted, demonstrating the increased sensitivity of our space surveillance system.

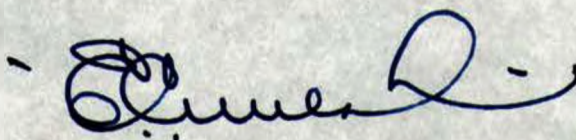
9. ComSat Corp. Successful two-way trans-Atlantic television tests were conducted via the Early Bird satellite between the United States and Germany, France, and England. An hour-long inaugural program will be shown on the national networks on May 2.

10. Research grants. The DOD has awarded research grants in the amount of \$25 million in calendar year 1964 to U. S. and foreign non-profit institutions. Of the funds for these 707 basic scientific research grants, \$2.45 million went for the 139 grants to foreign organizations.

11.

Space Payload Success Box Score
(April 30)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth Orbit	18	30	9	17
Escape	1	1	1	0



E. C. Welsh

(21)

EXECUTIVE

05

FG11-4



EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

April 23, 1965

EXECUTIVE SECRETARY

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress

a. Methods of strengthening basic research will be the subject of a panel meeting between the House Committee on Science and Astronautics and the National Academy of Sciences April 26.

b. The House Science and Astronautics Committee's work on the FY 1966 NASA authorization bill is expected to be completed next week.

c. The House Government Operations Committee is expected to issue soon a report which will evaluate Government operations in space.

2. Launches

a. The Soviet Union launched Cosmos 65 into a low earth orbit April 17. Previous launches of this type have been recovered after 8 days.

b. The Soviet Union launched a communications satellite, Molniya 1, into a highly elliptical orbit, April 23. They announced successful television relay between Vladivostok and Moscow via the satellite at its 24,000 mile apogee.

3. Pending Launches

a. The second manned Gemini space capsule is scheduled for launch in early June. Space suits, which would be necessary if the astronauts were to be exposed to the space environment, will be worn. There is a possibility that the hatch will be opened while the capsule is in orbit. Schedule for the first extra-vehicular activity for the third manned Gemini launch is planned for later this year.

b. A beacon Explorer will be launched by a Scout vehicle from Wallops Island April 28. It will make gravitational measurements and serve as a geodetic reference.

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APR 23 1965
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4. XB-70 Sets Records. The Air Force XB-70 experimental supersonic aircraft broke all endurance speed records April 21 by flying for one hour and 11 minutes at supersonic speeds, including 53 minutes at speeds exceeding Mach 2.

5. Apollo

a. The first two unmanned flights of the Apollo lunar spacecraft are scheduled for early next year. The first will be a ballistic shot from Cape Kennedy. The second will be an orbital flight to test the Service Module's propulsion system and the heat shield of the reentry recovery system. Both spacecraft will be launched by the Saturn IB booster.

b. A static test of all five engines of the Saturn V booster, scheduled to send the Apollo spacecraft to the moon, was conducted April 16. 7.5 million pounds of thrust were developed.

6. Nuclear Rocket Test. The first full power, full duration ground test of the Nerva nuclear engine is scheduled today at Jackass Flats, Nevada.

7. SNAP. NASA has advised the AEC that it expects to use thermal kilowatts of radioisotopes in increased quantities above stockpiled amounts between now and 1980. New missions possibilities are anticipated.

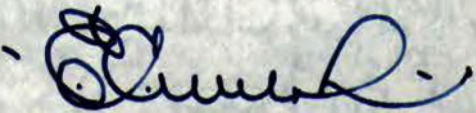
8. Mercury. Most recent radio astronomy readings indicate that the planet Mercury does not keep one face to the sun as previously thought, but rotates on its own axis in somewhat less time than its year, which is 88 earth days long. This information has led some astronomers to conclude that Mercury was once a moon of Venus, and that its composition is much like that of the earth's moon.

9. Eurospace. Representatives of European industrial organizations, which are members of Eurospace, will hold meetings in the United States and visit U. S. Government and private contractor space facilities from April 26 to May 7.

10.

Space Payload Success Box Score
(April 23)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth Orbit	16	26	8	16
Escape	1	1	1	0


E. C. Welsh



EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE

OS

FG 11-4

EXECUTIVE SECRETARY

April 16, 1965

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities.

1. Congress

a. The House Science and Astronautics Committee has postponed final action on the NASA FY 1966 authorization until April 27.

b. The Committee also has released its report on aeronautics. Among the conclusions in the report are that we should proceed to maintain this country's leadership position in aviation technology and that we should consider moving faster in taking action regarding a supersonic transport.

2. Space Council. Under chairmanship of the Vice President, a Council meeting was held April 13. The subject stressed was how should we expand the international aspects of our space program.

3. Space Mystery. Soviet radiotelescopes have found a strange pattern of radio signals from a source in outer space. First Soviet reactions were that this was evidence of the existence of intelligent beings out in space; upon reflection, these reactions have been discounted.

4. Launches. A Blue Scout Jr. launch vehicle rocketed biological experiments to an altitude of 18,000 miles April 9. This Department of Defense probe burned up on reentry after having returned several hours of useful data. One of the experiments was to study the effects of space radiation on human tissue.

5. Early Bird. The first commercial communications satellite is undergoing final maneuvers that will place it in a "stationary" position over the equatorial Atlantic. Communication tests with the ground terminal at Andover, Maine have been satisfactory and tests with European terminals are now being conducted. An inaugural inter-continental TV program is planned for May 2.

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APR 20 1965
CENTRAL FILES

6. Nuclear space uses.

a. The next test of AEC Nerva reactor, part of the program to produce a nuclear rocket engine, is scheduled for April 23 at Jackass Flats, Nevada.

b. The first nuclear reactor (Snap 10-A) in space is operating satisfactorily and has proved the feasibility of launching, operating, and monitoring reactors in space.

7. Bermuda Tracking Station. NASA will establish a \$10 million Apollo tracking station to expand the facilities at the Cooper's Island Bermuda site.

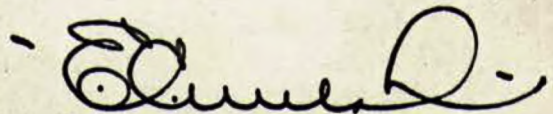
8. Apollo Assembly Building. The last steel beam was hoisted atop the world's largest man-made structure this week at Cape Kennedy. This signifies virtual completion of the 57,000 ton structural steel skeleton of the building for assembly of the Saturn V launch vehicles that will propel U.S. astronauts to the moon.

9. 260 Inch Solid. Failure of the casing of a large 260 inch solid rocket under hydrostatic testing is the first adverse technical feature which has developed in this program.

10. Ranger. U.S. scientists are publicly continuing their debates on the strength of the lunar surface. The Ranger photos have not resolved the question of whether the surface will support the lunar landing spacecraft. The Ranger project has, however, expanded greatly our scientific knowledge of the moon.

11. SPACE PAYLOAD SUCCESS BOX SCORE
(April 16)

	USA		USSR	
	1964	1965	1964	1965
Earth Orbit	12	26	8	14
Escape	1	2	1	0



E. C. Welsh

EXECUTIVE

PR 15-4

FG 11-1

ND

OS

4/12/65

TO: Mrs. Juanita Roberts

Back of front page of
x Aerospace Industries Association
Magazine.

E. C. Welsh



EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE
OS
FG11-4

April 2, 1965

EXECUTIVE SECRETARY

MEMORANDUM TO THE PRESIDENT

Subject: Space Activities

1. Congress

a. The Senate Committee on Aeronautical and Space Sciences has completed hearings on NASA's FY 1966 Authorization.

b. Among the conclusions of the report of the House Science and Astronautics Committee panel meeting on aeronautics, to be made public on April 8, are that (1) an insufficient amount of research is being conducted on hypersonic flight and (2) NASA's aeronautical research and development capabilities are not being used to their maximum capacity.

2. Pending launches

a. SNAP 10A, the first nuclear reactor scheduled for space flight, is to be launched this week-end.

b. Launch of the Communications Satellite Corporation's "Early Bird" satellite is scheduled for April 6. If successful, trans-Atlantic communications services will be available on a regular basis as early as June.

3. Mapping satellites. The Department of Defense has now publicly revealed that it has placed three geodetic satellites in orbit. One was launched 15 months ago and two were placed in orbit earlier this month.

4. Weather satellite anniversary. Tiros I, the world's first weather satellite, was launched five years ago April 1. The nine weather satellites launched to date have returned close to a half million useful pictures, discovered 50 hurricanes, and have led to the issuance of more than 2100 storm bulletins to over 50 countries. A model of Tiros I was given to the Smithsonian Institution to celebrate the event.

5. Mariner. This planet-photographing mission is proceeding on schedule. The spacecraft has completed more than half of its 228-day journey to Mars and has traveled more than 200 million miles.

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APR 5 1965
CENTRAL FILE

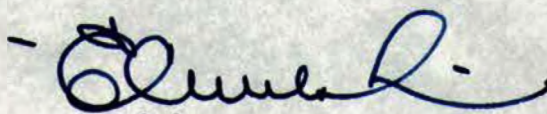
6. Amateur radio satellite. The OSCAR III communications satellite built and operated by amateur radio operators ("hams") has provided two-way radio communications over 7000 miles, almost double its theoretical line of sight range. This performance lends credibility to a "ducting" theory of radio propagation.

7. Quiet Sun. Scientists from many parts of the world will converge on four small islands of the South Pacific May 30 to view the 38th total eclipse of the sun this century as part of the International Quiet Sun Year.

8. Radiation probe. The Air Force launched a Blue Scout Jr. March 30. The probe's sensing devices measured variations in the charged particles trapped in the earth's magnetic field.

9. Space Payload Success Box Score
(April 2)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth orbit	15	24	5	14
Escape	1	2	0	0



E. C. Welsh



EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE 18
05
FC11-4

EXECUTIVE SECRETARY

April 8, 1965

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress

a. The House Armed Services Investigation Committee is scheduled to begin hearings late this month in connection with the investigation of the Aerospace Corporation. Contention is that the Corporation has made excessive expenditures on public relations over the period of the last four years.

b. The House Science and Astronautics Committee plans to clear the NASA Authorization bill out of the Committee by the Easter recess. The Committee figure is expected to be close to that requested.

2. Launches

a. SNAP 10A became the first nuclear reactor to be orbited in space, April 3. Placed in a very long life polar orbit of 800 miles altitude, the reactor is producing up to about 660 watts of electric power. Some of the power was applied to drive an ion engine. Static in the electrical signals suggests the ion engine may not be functioning as intended, so this part of the experiment has been suspended, at least temporarily.

b. The Communications Satellite Corporation's "Early Bird" satellite was launched April 6 and placed into a synchronous orbit April 9. NASA handled the launch. Positioned over the South Atlantic the satellite has the capability to relay television or as many as 240 concurrent telephone calls. Communication tests have been successful.

3. Gemini. The capsule to be used in the second manned Gemini flight has been delivered to Cape Kennedy. The four-day mission is expected in early June.

4. Ship launches. NASA's sea-going sounding rocket platform, the USNS Croatan, has launched 46 sounding rockets on scientific missions.

5. Propulsion. The Air Force has successfully tested a new concept rocket engine called Scorpio. Eight 25,000-pound thrust chambers or

combustors are placed in a ring around the nozzle. The rocket developed 200,000 pounds of thrust in two tests at Edwards Air Force Base.

6. Titan launches. Two launches of the Titan III launch vehicle are scheduled for May. A Titan III-A is scheduled for launch approximately May 3, and the Titan III-C (a Titan III-A with two large solid boosters strapped on to it) is scheduled for launch in late May. When developed, the Titan III-C will have the capability of placing approximately 25,000 pounds of payload in low-earth orbit.

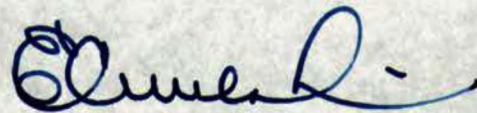
7. Weather satellites

a. The U. S. and France are discussing a cooperative program whereby U. S. weather satellites acquire data from constant-level balloons of French design.

b. Picture quality of Camera 1 in the Tirox IX has degraded so severely over the past few days as to be unusable for cloud analysis purposes. Camera 2 continues to function normally, but coverage has been reduced.

8. Space Payload Success Box Score
(April 9)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth orbit	16	26	7	14
Escape	1	2	1	0



E. C. Welsh

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
OFFICE OF THE ASSOCIATE ADMINISTRATOR

2/17/65

Mr. Barber:

Enclosed you will find a
possible covering summary memorandum
for the President, as per your
request.

Rest.

Robert C. Seamans, Jr.

RECEIVED
FEB 19 1965
CENTRAL FILES

MEMORANDUM

THE WHITE HOUSE
WASHINGTON

April 1, 1965

05
FG 260
FG 431/AERONAUTICAL
+ SPACE SCIENCES
FG 411/SCIENCE &
ASTRONAUTICS

MR. PRESIDENT:

Attached is the file on a suggested letter from James Webb
to Senator Anderson and Congressman George Miller.

You indicated your slight discontent.

Webb says: The letter is consistent with your policies,
and with the budget this year.
Moreover, it is a conservative approach; ~~whether~~
whether you choose or not to choose to finance
any of these projects is still within your choice.
You are completely flexible.
Webb feels that something should go to these two
chairmen, since they know about the report and
ought to get some kind of transmittal with it.

Webb favors the attached letter.

Jack Valenti

RECEIVED
APR 3 1965
CENTRAL FILES

Called Jim Webb's
Secretary. Told
her letter approved.
They will send it
out. 4-2-65
12:00
M. White

MEMORANDUM

THE WHITE HOUSE
WASHINGTON

March 30, 1965

MR. PRESIDENT:

Administrator James Webb, NASA, would like to
send the attached letter to Senator Anderson and Congressman
Miller if you approve.

Approved ✓

Not Approved

*If necessary ✓
Why do we need
to do anything -*

I would think I would have more

Jack Valenti

*decreasing & increasing money by
saying nothing which I would
prefer - R*

*committee write
budget this year -*

*next year - finance
or not these
projects*

*conservative
approach*

orig. Sent to Mr. Valenti



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. 20546

IN REPLY REFER TO:

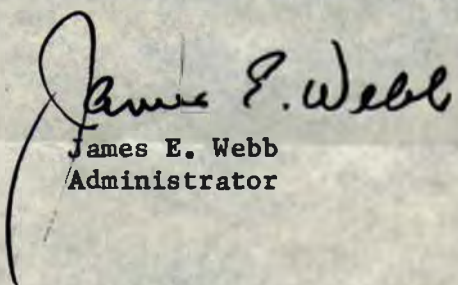
March 30, 1965

MEMORANDUM TO: Mr. Jack Valenti
Special Assistant to the President
The White House

In accordance with your request telephoned to me yesterday, enclosed is a draft of a letter I could use to transmit the Future Programs Task Group Summary to Senator Anderson and Congressman Miller for use in their committees. At the same time I would transmit a copy of my letter of February 16, 1965 to the President and would discuss with the two chairmen a time and method for public release. They might agree to issue it as a committee document.

This has considerable value in giving the committees an opportunity to see this report before they act on the budget. It also gets the material both before the Congress and before the public without commitment by the President of a future position.

You will note the statement that the Fiscal Year 1966 budget is based on the material used in this report but that it does not represent a projection for either the President or for NASA.


James E. Webb
Administrator

D R A F T

Honorable Clinton P. Anderson
Chairman
Committee on Aeronautical and Space Sciences
United States Senate
Washington, D. C.

Honorable George P. Miller
Chairman
Committee on Science and Astronautics
House of Representatives
Washington, D. C.

Dear Mr. Chairmen:

During my appearances before the Senate Committee on Aeronautical and Space Sciences and the House Committee on Science and Astronautics on the President's budget for Fiscal Year 1966, a number of questions were asked about the program for future years and whether the level recommended by the President for Fiscal Year 1966 (five and one quarter billion dollars) will be maintained for the rest of this decade. In reply, I stated that our future programming was under discussion with the White House and that better answers could be provided later in the hearings.

The President has now authorized me to transmit to you the enclosed summary of our Future Programs Task Group, together with my letter of February 16, 1965 to him, replying to certain questions which he asked in the period following the decisions on the budget for Fiscal Year 1965.

Also enclosed is an interim reply sent the President on May 20, 1964.

In submitting this material, I should like to make clear that the Future Programs Task Group Summary is primarily a statement of capabilities recently developed or currently under development and of certain ways in which these capabilities might be effectively employed in the period following the completion of the build-up required by current programs. It also presents a discussion of the advancements in technology needed to carry out a number of long-range missions.

Although this report is based on material developed for the Fiscal Year 1966 budget, I should emphasize that it does not represent a projection of what the National Aeronautics & Space Administration will recommend to the President for inclusion in the 1967 and the following year budgets. It also does not represent the President's views as to what he is prepared to approve for Fiscal Year 1967 and the years that follow.

My request to the President for authorization to present this letter and summary report to the committees is directly related to the statement in the final paragraph of my letter to the President that a basis for a national consensus with respect to programs to be undertaken as follow-on to those that are already approved needs an informed public discussion and debate. I feel that this report will make an important contribution to this process and hope it will be helpful to the committees in their reviews of the space program.

Sincerely yours,

James E. Webb
Administrator

EXECUTIVE 4+

OS

FG 260

PAI/FG 260

FG 11-9

FG 726

March 27, 1965

MEMORANDUM FOR

Honorable James E. Webb
Administrator
National Aeronautics and Space Administration

I was pleased to receive your letter of February 16, 1965, setting forth so clearly the general goals of NASA's programs, as well as the Summary Report of the Future Programs Task Group.

Dr. Hornig and my Science Advisory Committee have reviewed the Task Group's Report for me and recommend its publication. I have accepted this recommendation and would like NASA to proceed with publication of the Summary Report of the Future Programs Task Group.

However, I think it would be wise if such publication were accompanied by a statement from you clarifying the purpose of the Report. In particular, your statement should make it clear that the Report is not itself the proposed content of our future space program, but rather a description of present and potential space capabilities which must be taken into account in formulating the future program.

LBJ; DFH; eac

cc: The President's Files
WH Central Files (2)
Dr. Hornig, R. 200, EOE

*Pres has Oversee Attached
1 Copy Report Attached
to back of Case*

March 27, 1965

MR. PRESIDENT:

Dr. Hornig and I recommend that you sign
the attached memorandum.

It merely underscores the fact that Jim
Webb's report of future space programs
is not a commitment but merely potential.

Jack Valenti

3/23
Dr. Hornig will
prepare memo.
Webb.

THE WHITE HOUSE
WASHINGTON

March 19, 1965

MEMORANDUM FOR

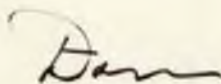
Mr. Valenti

Subject: NASA's "Summary Report of the Future Programs
Task Group."

The last and the next to the last editions of this report have been reviewed in detail by the Space Science Panel of the PSAC. In addition, this Panel's recommendation as to the manner of the report's public release was discussed, and accepted, by the President's Science Advisory Committee at its meeting of March 15-16. The Panel's statement in this connection was as follows:

"Recommendation as to Procedure for Public Release of the SRFPTG. The Panel considered that probably the most appropriate way in which to release the report is to have NASA do so but with an accompanying statement from the Administrator making it clear that the document is not a program description but a summary of technical capabilities available for making program choices. Thus, the statement should make it quite clear that the SRFPTG is not a document soliciting proposals for all of the possible programs implied by it. In particular, the Panel agreed that release of the SRFPTG through OST or the White House would result in much more public attention to the document than seems either appropriate or potentially useful."

I concur in this view, and recommend that the President so advise Mr. Webb.



Donald F. Hornig
Special Assistant for
Science and Technology

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MAR 25 1965
CENTRAL FILES

THE WHITE HOUSE

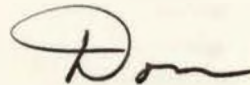
WASHINGTON

March 26, 1965

MEMORANDUM FOR

Mr. Valenti

Attached is the memorandum from the President to Jim Webb that you requested as a follow-up to my previous memorandum submitting my recommendation.



Donald F. Hornig
Special Assistant for
Science and Technology

Attachment

RECEIVED
MAR 29 1965
CENTRAL FILES

EXECUTIVE

OS

FS 115

TC 440

FC 400

FG 11-4

FG 260

Why don't you go ahead and distribute copies of the NASA report to Ed Welsh, Secretary McNamara, and the Vice President.

JV:ny

Preu has Oversight Attachments

After copies in oversize w/ prev Oversize

MEMORANDUM

THE WHITE HOUSE
WASHINGTON

March 1, 1965

MEMORANDUM FOR THE PRESIDENT

Administrator Jim Webb says that the attached copy of the NASA report is so far closely held.

He thinks that for immediate purposes copies should be sent to Ed Welsh, Secretary McNamara, and the Vice President.

For the long-range future, he suggests broad distribution including transmittal to the Congress by either the President or NASA.

He thinks that this broad distribution might wait until the President makes a major speech on space. What are your views, Sir?

(1) Distribute copies to Welsh, McNamara and the Vice President?

(2) Broad distribution to the Congress now?

(3) Wait on this.

Jack Valenti

see over 1

Per conversation with Mrs Nell Yates. - President changed his
mind and did not want the distribution to Congress.

MEMORANDUM

THE WHITE HOUSE

WASHINGTON
March 1, 1965

MR. VALENTI

Jim Webb tells me that besides our office and NASA, the only copies of the report are in Hornig, Kermit Gordon, and Horace Busby's offices.

He thinks that for immediate purposes we should send copies to

- Ed Welsh
- The R Vice President
- Secretary McNamara

For the long-range future he suggests broad distribution including transmittal to the Congress by either the President or NASA. The question of timing he leaves to us. He suggests that perhaps the President might want to save it until he makes a major speech in this area.

Perry Barber

THE WHITE HOUSE
WASHINGTON

February 17, 1965

MR. PRESIDENT:

The attached NASA report recommends:

- Report filed - OVERSIGHT ATTACHMENT (2 copies) (1 copy attached to back of book)*
1. Early initiation of a large soft-landing spacecraft project for the unmanned exploration of Mars, with landings to occur in 1971 and a possible fly-by in 1969.
 2. Use of the Apollo-LEM system for additional earth-orbit flights and its improvement to permit longer lunar stay time.
 3. Continuation of a high level of effort in the areas of research and advanced technical development.
 4. Deferral of decisions on major new projects, such as permanent space stations or manned planetary exploration, until information and capabilities are in hand to provide a better basis for judgment.

These recommendations require no major new launch vehicle systems beyond those now under development and assume that resources on the order of those currently programmed (\$51/4 billion per year) will continue to be available for conduct of space and aeronautics activities.

RECEIVED
FEB 18 1965
CENTRAL FILES

*Report per President's req. 11/30/64
Preliminary Report Oct 5/20/64
Final Report Jan. 1965*

attached

2.

Work to date on approved NASA programs has built a national capability for space exploration and use. This capability can be focussed in the near future on a number of space missions not requiring major new developments. In turn, these intermediate missions will provide a better basis for decisions as to the major new future projects which should be undertaken at a later time. The on-going, intermediate and future programs all depend upon a broadly conceived and continuing effort in basic and applied research, advanced technology, and prototype system development and testing.

Jack Valenti





NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON, D.C. 20546

OFFICE OF THE ADMINISTRATOR

February 16, 1965

The President
The White House

Dear Mr. President:

In further amplification of my response of May 20, 1964, to your request for an appraisal and assessment of future space programs to which the United States might need to commit major support, two objectives for the years just ahead appear to stand out above other possibilities. Both appear to be within the framework of feasible resource levels for FY 1967 and following years.

The first of these, which is strongly supported by the Space Science Board of the National Academy of Sciences, is the exploration of Mars through the use of large unmanned soft-landing spacecraft. This is a major undertaking with an eventual total program cost in excess of \$1 billion. If adopted now and the 1969 Mars near approach to the earth is chosen as the target date for beginning operational missions, the budget as approved for FY 1966 would require a supplemental request to augment the funds now in the budget, and the budget for FY 1967 must include substantial funds for this purpose.

Considering all factors, I believe we should focus on the later opportunity that will come in 1971. A program to this end is recommended. If prompt approval is given, it may be that one or more fly-by or orbiting test flights can be launched to Mars during the favorable opposition of 1969. These test flights would increase significantly our chances for success in 1971.

The second objective is a systematic program extending over several years to capitalize on the availability of the Saturn boosters and the Apollo-LEM manned space flight system for a wide variety of worth-while scientific and technical missions in near-earth and synchronous orbits, in lunar orbit, and on the lunar surface. This recommendation is based on emerging scientific and technical trends and the further application of

the large capabilities for manned space activities that we are in the process of establishing. There is clearly open to us a very real opportunity to build on and make further use of the Mercury, Gemini and Apollo experience and the manned space equipment we are now developing in the Apollo program. The resources of the Apollo-LEM system, of the Saturn family of launch vehicles, and related launch facilities, and of our Integrated Mission Control Center and world-wide net of stations can provide the necessary combination of ground-based resources, space flight equipment, and know-how to undertake post-Apollo follow-on manned scientific, developmental and application missions, having both non-military and military significance, that will go a long way toward guaranteeing our future in space. Our studies indicate that this is the most effective and efficient way to extend into the new medium of space the leadership we now have in aeronautics.

The scientific and engineering manpower, facilities, industrial capacity, and managerial skill now in being would be utilized in both the Mars exploration and post-Apollo missions and thus be maintained in a status that could be augmented rapidly should a need arise.

An important element is that these two objectives would provide a focus for our space activities and bring about an integrated approach to our work, which is one of our basic strengths. Further, this puts us in a position of defining a challenging program and pursuing it, rather than responding to challenges brought about by the activities of others. Well-defined, near-term goals are needed, too, in order to stimulate and direct the advances in supporting research and technology that are so vital to the successful achievements of these new missions.

With respect to longer range missions in the 1970's and 1980's, the attached report of the Future Programs Task Group identifies a substantial number which the Nation may in the future find necessary or desirable for preeminence in space and for its full utilization. Those offering greatest promise in the manned area are: systematic lunar exploration, large orbiting space stations, and manned exploration of Mars. These, together with unmanned exploration of comets, asteroids, and the more distant planets and of the inner and outer reaches of interplanetary space all portend a new era of understanding for man, particularly of the origin and evolution of the Sun and the planets, about which he has conjectured for so many centuries.

The economic, social, and political future of this country and its position in the world are related to satellites for global coverage of meteorological phenomena, for broadcasting direct to home receivers and for the navigation and traffic control of ship and aircraft; and new aircraft concepts and capabilities. The possibilities emerging from aeronautics research for routine flight at zero forward speed, cruising flight at six to eight times the speed of sound, and flight systems with the flexibility to serve all communities and urban centers have very far-reaching implications.

Our past experience in aeronautics and space has shown the great value of maintaining a high level of effort in a broad spectrum of science and technology to provide the underlying competence essential to exercise responsible judgment as needs arise in the choice of new objectives and in insuring their efficient accomplishment. Our present programs of basic and applied research, and systems development projects have been so organized as to supply a basis for judgment and to make available true technical options at times of decision on missions that will require capabilities beyond those now available.

Urgent, currently definable, needs for launch vehicles over the next ten years can be met by systems existing or already under development. The boosters in the National Launch Vehicle Program are under constant review. Our objective is to eliminate any that are uneconomical for the needs we now see. Our present level of research and technology will enable us to steadily improve and up-rate those vehicles retained.

The Nation has reason to be proud of its accomplishments in space, particularly in view of its late start. The national security and the national welfare have profited from the successful scientific and technological strides that we have taken, and our extending of these new frontiers has greatly reduced the risk that we will be subject to some critical new challenge in either the military or non-military uses of space.

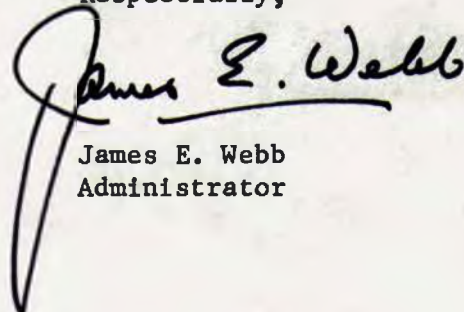
As in any new field of endeavor, it is wise to select the next steps in the exploration of space to provide both immediate useful return and the strengthening of a foundation for succeeding forward thrusts.

In my view, a strong effort in the exploration of Mars, particularly in a search for life on that planet, coupled with an attack on scientific and technical problems related to the effective use of man in space through follow-on flights with the Apollo-LEM system, will round out and strengthen our basic on-going space effort and thus efficiently and at acceptable cost insure that we have the essential basic elements for a continuing strong, well-balanced program. Joint planning of these programs with the Department of Defense and participation in their execution by the military services will substantially add to their knowledge of space operations and to our total national ability to apply sound judgment in the selection of the most beneficial future missions, whether civilian or military. Also, this will give a far better ability to time future missions to our greatest advantage.

Our capability for aeronautical and space advance will also be increased by the continuation and expansion of programs to disseminate the new technology to industry, to stimulate university research and training, and to support foreign policy objectives through useful projects of international cooperation in space research and technology.

More than in most areas, major decisions on space require a broad consensus. During the next several years it is likely that the selection of major new space missions will be the subject of serious study and debate by many individuals and agencies in public and private walks of life. For these reasons, it may be desirable at an appropriate time to make the attached report generally available. We are prepared to do this if you feel that it will serve a useful purpose.

Respectfully,

A large, stylized handwritten signature in dark ink, reading "James E. Webb". The signature is written over the typed name and title.

James E. Webb
Administrator

Enclosure

3 copies NASA "Summary Report -
Future Programs Task Group"
dated January 1965

D R A F T

MEMORANDUM FOR THE PRESIDENT

On January 30, 1964, you requested the Administrator of NASA to review future space exploration plans with emphasis on:

- (1) Possible space objectives beyond those already approved,
- (2) Advances in space technology necessary to support such objectives,
- (3) NASA or DOD requirements over the next decade for new boosters beyond those under development,
- (4) Time and resource estimates for the overall program.

Mr. Webb has kept in close touch with the Director of the Budget and Dr. Hornig to make sure his report would not come at an undesirable time or in a form you would find inconsistent with your budget or other plans. The attached letter and report from Mr. Webb respond to your questions in depth. The findings and recommendations are summarized below:

Work to date on approved NASA programs has built a ~~great~~ ^{capability} national capability for space exploration and use. This can be focussed in the near future on a number of space missions not requiring major new developments. In turn, these intermediate missions will provide a better basis for decisions as to the major new future projects which should be undertaken at a later time. The on-going,

Insert
A

intermediate and future programs all depend upon ~~the~~ ~~a~~

~~kind of~~ broadly conceived and continuing effort in basic

and applied research, advanced technology, and prototype

system development and ^{testing,} ~~test, which has become NASA's trade~~

~~Within this framework, the following recommendations are made:~~

1. ~~(X)~~ Early initiation of a large soft-landing spacecraft project for the unmanned exploration of Mars, with landings to occur in 1971 and a possible fly-by in 1969.

2. ~~(X)~~ Use of the Apollo-LEM system for additional earth-orbit flights and its improvement to permit longer lunar stay time.

3. ~~(X)~~ Continuation of a high level of effort in the areas of research and advanced technical development.

4. ~~(X)~~ Deferral of decisions on major new projects, such as permanent space stations or manned planetary exploration, until information and capabilities are in hand to provide a better basis for judgment.

These recommendations require no major new launch vehicle systems beyond those now under development and assume that resources on the order of those currently programmed (\$5½ billion per year) will continue to be available for conduct of space and aeronautics activities.

A →

Jack Valenti



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON 25, D.C.

OFFICE OF THE ADMINISTRATOR

February 16, 1965

The President
The White House

Dear Mr. President:

In further amplification of my response of May 20, 1964, to your request for an appraisal and assessment of future space programs to which the United States might need to commit major support, two objectives for the years just ahead appear to stand out above other possibilities. Both appear to be within the framework of feasible resource levels for FY 1967 and following years.

1. The first of these, which is strongly supported by the Space Science Board of the National Academy of Sciences, is the exploration of Mars through the use of large unmanned soft-landing spacecraft. This is a major undertaking with an eventual total program cost in excess of \$1 billion. If adopted now and the 1969 Mars near approach to the earth is chosen as the target date for beginning operational missions, the budget as approved for FY 1966 would require a supplemental request to augment the funds now in the budget, and the budget for FY 1967 must include substantial funds for this purpose.

Considering all factors, I believe we should focus on the later opportunity that will come in 1971. A program to this end is recommended. If prompt approval is given, it may be that one or more fly-by or orbiting test flights can be launched to Mars during the favorable opposition of 1969. These test flights would increase significantly our chances for success in 1971.

2. The second objective is a systematic program extending over several years to capitalize on the availability of the Saturn boosters and the Apollo-LEM manned space flight system for a wide variety of worth-while scientific and technical missions in near-earth and synchronous orbits, in lunar orbit, and on the lunar surface. This recommendation is based on emerging scientific and technical trends and the further application of

the large capabilities for manned space activities that we are in the process of establishing. There is clearly open to us a very real opportunity to build on and make further use of the Mercury, Gemini and Apollo experience and the manned space equipment we are now developing in the Apollo program. The resources of the Apollo-LEM system, of the Saturn family of launch vehicles, and related launch facilities, and of our Integrated Mission Control Center and world-wide net of stations can provide the necessary combination of ground-based resources, space flight equipment, and know-how to undertake post-Apollo follow-on manned scientific, developmental and application missions, having both non-military and military significance, that will go a long way toward guaranteeing our future in space. Our studies indicate that this is the most effective and efficient way to extend into the new medium of space the leadership we now have in aeronautics.

1.2. The scientific and engineering manpower, facilities, industrial capacity, and managerial skill now in being would be utilized in both the Mars exploration and post-Apollo missions and thus be maintained in a status that could be augmented rapidly should a need arise.

An important element is that these two objectives would provide a focus for our space activities and bring about an integrated approach to our work, which is one of our basic strengths. Further, this puts us in a position of defining a challenging program and pursuing it, rather than responding to challenges brought about by the activities of others. Well-defined, near-term goals are needed, too, in order to stimulate and direct the advances in supporting research and technology that are so vital to the successful achievements of these new missions.

II
With respect to longer range missions in the 1970's and 1980's, the attached report of the Future Programs Task Group identifies a substantial number which the Nation may in the future find necessary or desirable for preeminence in space and for its full utilization. Those offering greatest promise in the manned area are: systematic lunar exploration, large orbiting space stations, and manned exploration of Mars. These, together with unmanned exploration of comets, asteroids, and the more distant planets and of the inner and outer reaches of interplanetary space all portend a new era of understanding for man, particularly of the origin and evolution of the Sun and the planets, about which he has conjectured for so many centuries.

VII

The economic, social, and political future of this country and its position in the world are related to satellites for global coverage of meteorological phenomena, for broadcasting direct to home receivers and for the navigation and traffic control of ship and aircraft; and new aircraft concepts and capabilities. The possibilities emerging from aeronautics research for routine flight at zero forward speed, cruising flight at six to eight times the speed of sound, and flight systems with the flexibility to serve all communities and urban centers have very far-reaching implications.

Our past experience in aeronautics and space has shown the great value of maintaining a high level of effort in a broad spectrum of science and technology to provide the underlying competence essential to exercise responsible judgment as needs arise in the choice of new objectives and in insuring their efficient accomplishment. Our present programs of basic and applied research, and systems development projects have been so organized as to supply a basis for judgment and to make available true technical options at times of decision on missions that will require capabilities beyond those now available.

Urgent, currently definable, needs for launch vehicles over the next ten years can be met by systems existing or already under development. The boosters in the National Launch Vehicle Program are under constant review. Our objective is to eliminate any that are uneconomical for the needs we now see. Our present level of research and technology will enable us to steadily improve and up-rate those vehicles retained.

The Nation has reason to be proud of its accomplishments in space, particularly in view of its late start. The national security and the national welfare have profited from the successful scientific and technological strides that we have taken, and our extending of these new frontiers has greatly reduced the risk that we will be subject to some critical new challenge in either the military or non-military uses of space.

As in any new field of endeavor, it is wise to select the next steps in the exploration of space to provide both immediate useful return and the strengthening of a foundation for succeeding forward thrusts.

In my view, a strong effort in the exploration of Mars, particularly in a search for life on that planet, coupled with an attack on scientific and technical problems related to the effective use of man in space through follow-on flights with the Apollo-LEM system, will round out and strengthen our basic on-going space effort and thus efficiently and at acceptable cost insure that we have the essential basic elements for a continuing strong, well-balanced program. Joint planning of these programs with the Department of Defense and participation in their execution by the military services will substantially add to their knowledge of space operations and to our total national ability to apply sound judgment in the selection of the most beneficial future missions, whether civilian or military. Also, this will give a far better ability to time future missions to our greatest advantage.

Our capability for aeronautical and space advance will also be increased by the continuation and expansion of programs to disseminate the new technology to industry, to stimulate university research and training, and to support foreign policy objectives through useful projects of international cooperation in space research and technology.

More than in most areas, major decisions on space require a broad consensus. During the next several years it is likely that the selection of major new space missions will be the subject of serious study and debate by many individuals and agencies in public and private walks of life. For these reasons, it may be desirable at an appropriate time to make the attached report generally available. We are prepared to do this if you feel that it will serve a useful purpose.

Respectfully,

Original Signed BY :
James E. Webb

James E. Webb
Administrator

Enclosure

3 copies NASA "Summary Report -
Future Programs Task Group"
dated January 1965

filed Overidge

EXECUTIVE
051 Galt
Ed Welsh
Called Dr. Hornig's
office 8/31 - he was
on vacation. Ed Sep 14/64
Hornig

THE WHITE HOUSE
WASHINGTON

August 27, 1964 F

MEMORANDUM FOR

Walter Jenkins

On January 30 the President, at my suggestion, sent a letter to NASA requesting a study of possible future space programs and their relation to present planning with a report by September 1st. The attached copy of a letter from me to Dr. Seamans of NASA confirmed my concurrence in extending the due date of this report to the end of the year. The extension also had the concurrence of Mr. Gordon of BOB and Dr. Welsh.

In view of the above, I would have supposed that Jim Webb's letter in response to my discussions with NASA would have been sent to me. I am a little at a loss as to what to do now, since I understand that Jim's letter was transmitted by your office to Ed Welsh for action. I really do think this matter belongs here. On the assumption that Ed has been asked to draft a reply for the President, I will send over an alternative draft tomorrow so that the President can take his choice.

RECEIVED
AUG 31 1964
CENTRAL FILES

Donald F. Hornig
Donald F. Hornig
Special Assistant for
Science and Technology

Encl. _____

EXECUTIVE

DSI
FG 260
FG 11-4

August 24, 1964

MEMORANDUM FOR
DR. EDWARD C. WELSH

For appropriate action.

Paul M. Popple
Assistant to
Walter Jenkins

Attachment

PMP:aer

Ltr to Pres fm Jas E Webb, NASA Admr,
dtd Aug 21, 1964, ref interim reply May 15
re review of poss objectives & missions in
space beyond those now approved; and re-
questing permission to begin discussions with
Pres's staff by or before Oct 1.

(to Dr Welsh, Exec Secy, Natl Aeronautics & Space Council)

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AUG 25 1964
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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WASHINGTON 25, D.C.

OFFICE OF THE ADMINISTRATOR

August 21, 1964

*F. August +
previous file
to Mr. Jenkins*

The President
The White House
Washington, D. C.

Dear Mr. President:

In your letter to me of January 30, you directed the National Aeronautics and Space Administration to review possible objectives and missions in space beyond those now approved, together with the supporting research and technology required to perform the mission. An interim reply was sent you on May 15. You asked for a final reply on September 1. *not in file*

All elements of the National Aeronautics and Space Administration have participated during the past months in a careful search for the objectives in scientific investigation, in manned flight, in lunar and planetary exploration, and in practical uses of space that will best serve the Nation's purpose to master and use this new environment. As objectives in space exploration have been defined, the missions and groups of missions required for their orderly accomplishment have been identified. To the fullest extent possible, the technical requirements of these missions, the realistic schedules on which they can be accomplished, and the resources needed have been set forth. Particular attention has been given to identifying the advances in technology, such as propulsion systems, electronic systems, and materials, that will be required to insure this Nation's mastery of space in the years ahead.

The results of these studies are now rapidly taking shape in the form of finished working papers, charts and graphs. I ask your permission to begin by October 1, if not earlier, to discuss these materials with members of your staff, with the staff of the Space Council, with the Office of Science and Technology, with the Bureau of the Budget, and with other appropriate agencies and persons in the Government, so that in the formulation of your plans and preparation of your messages to the Congress you will have before you carefully worked out and mature conclusions on this important matter.

RECEIVED
AUG 24 1964
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I suggest this procedure because the determination of the next stage of the space program is in all respects a national decision. The meaning of space exploration for international, military, scientific, and civilian affairs is increasing rapidly. It is essential that both our present capability and future programs be useful in the fullest possible way in support of all national purposes and goals.

In addition, there are several matters that relate directly to the making of the FY 1966 budget. These should be considered with the Bureau of the Budget in the light of the findings of the larger study that we have been carrying on in response to your letter.

Respectfully yours,

James E. Webb
Administrator

W H

August 11, 1964

Dear Bob:

I would like to take this opportunity to recapitulate the understanding that we came to yesterday concerning the NASA reply to the President's letter of January 30, as well as to summarizing my own concept of a format for the reply which would be responsive to the intent of that letter.

Briefly, our understanding covered the following points:

1. In view of the complexity of the task involved in formalizing a study of such scope as the reply entails, the official report replying to the President's letter would, subject to the President's approval, be submitted prior to January 1, 1965 instead of September 1, 1964, as originally requested.

2. As the various studies of alternative programs are brought together at NASA Headquarters during September, they will be made available to Executive Office staffs, so that my office, the BOB and the NASC will have an opportunity to consider the important alternatives and their scientific, technological, and program implications prior to NASA's submission of the 1966 budget estimates at the end of September. Presumably, the 1966 budget submission will reflect NASA management's preliminary conclusions as a result of its own appraisal of the alternatives.

3. Jim Webb will write a letter to the President requesting that the reply be handled according to the schedule outlined above.

As I discussed with you, I believe the official report to the President should not constitute a specific long range plan or program but rather should present a structure of alternative programs and their mutual interactions which will, in turn, provide an intellectual framework

- 2 -

from which future programs can be sensibly developed. In addition, it is my hope that during September my office and the PSAC Panels can have early opportunities to consider the various studies that you are collecting so that they can usefully interact with you and your staff during your formulation of the 1966 budget submission. I will count on you to take the initiative to let me know as studies become available for our consideration.

Sincerely,

D. F. Hornig
D. F. Hornig

Dr. Robert C. Seamans, Jr.
Associate Administrator
National Aeronautics and Space Administration
Washington, D. C.

CC: K. Gordon, BOB
E. C. Welsh, NASC
Bill D. Moyers, W.H.

DFH Chron
DHS Chron
DHS Subj
S&T Chron
S&T Subj

DHS:hk

NATIONAL AERONAUTICS and SPA COUNCIL

5/26/64

TO: Mr. George Reedy

Here is the "one-page synopsis"
of the Webb report which I
promised.



R. W. Hale

Attachment

RECEIVED
JUN 2 1964
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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS and SPACE COUNCIL

MEMORANDUM FOR MR. REEDY

Subject: Synopsis of Webb Letter of May 20 to the President on NASA Plans

NASA has virtually completed the investment in facilities to support the national goals in space which were proposed in May 1961, not only to land men on the Moon, but to meet a broad range of not yet specified tasks. Under the general Apollo label: For \$7.7 billion, we shall have launched 22 flights of Saturn I and IB, able to orbit 16 tons, and 15 flights of Saturn V, able to orbit 120 tons or send 45 tons to the Moon; For \$5 billion, we shall have an Apollo system able to maneuver near Earth and in deep space, to rendezvous in Earth and lunar orbit, to assemble components in orbit; For \$1.2 billion, Gemini and Titan II will have enabled us to conduct rendezvous and orbital experiments jointly for NASA and DOD; For \$1.7 billion we have acquired the facilities to support these vehicles; And for \$.9 billion, the tracking and data systems. Lesser investments have given us weather and communications satellites, and scientific orbital and deep space probes. The universities have been aided, and the Nation's research and industrial capabilities have been greatly enhanced.

These great tools and experience will be the basis for improving and enhancing our space capabilities to give practical meaning to all the work to which we are already committed. Possible new missions include: A far greater mastery of space science so that we have the intellectual basis for weather prediction and control; Exploration of the Moon to answer basic cosmological questions on the origin of the solar system; Exploration of the planets to seek life, and to understand its origins; Further development of flight technology designed to give us versatile, reusable vehicles, propelled by high energy chemicals, nuclear, and electrical propulsion systems, and carrying large capacity auxiliary power systems; Advanced electronics to give us fast and simple checkout of systems for reliability, and high capacity data transmission systems; Space medicine work to give us the capacity to send men on long voyages in good health. Nor is aeronautics being overlooked with VTOL and very fast flight at moderate cost and with safety as goals.

By September 1, detailed analyses will propose choices among more elaborate unmanned laboratories; an assortment of manned space stations; better weather, communications, and navigation satellites; thorough-going exploration of the Moon with instruments and men, including surface travel and bases; similar unmanned and manned exploration of at least the near planets; and finally, tentative probing of more distant planets, asteroids, and comets.

Current studies are trying to maximize the use which can be made of existing facilities and equipment, and to identify long leadtime work required to maximize the long run advantages to the Nation of an enhanced capability and of broader study, exploration, and application than has been attempted so far.

Charles S. Sheldon II
Charles S. Sheldon II

May 26, 1964

**EXECUTIVE****NATIONAL AERONAUTICS AND SPACE ADMINISTRATION**

WASHINGTON 25, D.C.

OFFICE OF THE ADMINISTRATOR

May 20, 1964

F
previous file
3 copies of the
Wally Jenkins
5/21/64

The President
The White House
Washington, D. C.

Dear Mr. President:

Your thoughtful letter of January 30 suggesting that we review our future space exploration plans with the object of relating hardware and development programs to prospective missions has been a subject of much thought for Dr. Dryden, Dr. Seamans, and myself, and our associates. We have been exploring the points suggested in your letter and laying the groundwork for the decisions to which you refer. Our full report will be in your hands by September 1, 1964.

I have discussed with Deputy Secretary Vance and Dr. Harold Brown your third point and its reference to research and development programs currently underway under the sponsorship of the Department of Defense. We have agreed to work together in preparing a response. Also, I have talked to Chairman Glenn Seaborg, of the Atomic Energy Commission, about joint work between now and September so you will have the benefit of his views, either directly or in the final report which I will send.

Dr. Harry Hess has offered the full cooperation of the Space Science Board of the National Academy of Sciences to insure that the views of the scientific community are reflected in the definition of the most important scientific aims and missions.

Nothing else sent to
Central Files as of 5/27/64

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MAY 22 1964
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OSI
OS 4
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FG 115
FG 202
FG 702

I.

Better than any other person, you know the frustration the nation experienced when it failed in 1957 to orbit a tiny three pound satellite at a time when the Soviet Union had already demonstrated a very large capability by orbiting one which weighed more than 1100 pounds. You have intimate personal knowledge of the national determination, embodied in the 1958 National Aeronautics and Space Act, to achieve pre-eminence in space. You also are thoroughly familiar with the actions taken in May of 1961, under your strong leadership, to expand the total space effort very substantially beyond the first budget augmentation of \$125 million that was approved by President Kennedy in March of 1961.

Since that time the National Aeronautics and Space Administration, with close cooperation and participation on the part of the Department of Defense, the Atomic Energy Commission, and the United States Weather Bureau, has moved well into a ten-year \$35 billion program aimed at developing a national capability for operations in space. This effort is directed toward vastly expanding our knowledge of the earth's atmosphere and the surrounding space, and applying this new knowledge for the benefit of mankind. This includes developing, testing, and putting into operational status manned systems which, in Gemini, will enable men to operate in orbit out to several hundred miles for periods up to two weeks, and, in Apollo, out to a quarter of a million miles, and, with modification, for periods up to two months, with the culminating objective of scientific exploration of the moon.

The industrial base and management system to build a manned space flight capability and to accomplish the Gemini and Apollo missions, which will involve an expenditure of \$20 billion over the ten years, are in being and have already demonstrated the ability to move ahead

with the job. Most of the nation's capital investment for manned space flight has already been made and the assembly, test and launch facilities are rapidly becoming operational. The same is true for the world-wide tracking and data acquisition network. In fact, the entire NASA capital budget for FY 1965 is down to \$280 million with a projected capital budget for 1966 of only about \$100 million to complete the facilities for already approved missions, manned and unmanned. We have indicated to the Director of the Budget that long lead time components of facilities that relate to future missions require consideration of an addition of about \$100 million to the 1966 NASA capital budget. If approved, this addition would make the total for 1966 \$200 for capital items.

The significance of the current ten year program and the capability being developed to serve the nation's long-range future needs is apparent in the investments which have been made and are now being made:

1. A \$7.7 billion investment in the design, fabrication, ground test, and flight test of Saturn boosters. This provides for:

22 flights of the Saturn I and IB, ending with a capability of placing up to 16 tons in orbit;

15 flights of the Saturn V, ending with a capability to orbit 120 tons and send 45 tons to the moon.

2. A \$5 billion investment in the design, fabrication, test, and proof of operational capability of the Apollo spacecraft with its accompanying lunar excursion module. This investment includes also the flight experience necessary to perfect the technique of joining the components of the spacecraft both in earth orbit and in orbit around the moon, the capability to launch the spacecraft from orbits around the earth toward the moon, and the ability to accomplish with large manned spacecraft the same kind of mid-course corrections already demonstrated so successfully with the small unmanned Ranger and Mariner spacecraft.

3. A \$1.2 billion investment in the Gemini 2-man orbital system, including the modification of the Titan II missile to adapt it for use as the Gemini launch vehicle; and the design, fabrication, test and proof of operational capability of the Gemini spacecraft, including the ability to rendezvous with a separately launched Agena target vehicle. This investment includes use of this combination over a period of several years to practice maneuvers in near-earth orbit and to perform twenty-three experiments jointly sponsored by DOD and NASA that are important for future manned space flight.

4. A \$1.7 billion investment in the planning, construction, and placing into operational use of those additional government financed facilities required for the development, test, and manufacture of the large Saturn boosters and the Apollo spacecraft. The Huntsville/Michoud/Mississippi Test/Houston/Cape Kennedy Complex and the supporting engine and booster test facilities in New Mexico and California and in other parts of the country will comprise an integrated system of facilities that can build and launch very large spacecraft over many years to come.

5. A \$900 million investment in the design, construction, checkout, and proof of operation capability of the world-wide command, tracking and data acquisition network for manned space flight. This investment includes putting into operation a system of stations, both land and sea-based, throughout the world, most of which are operated by American industry often with the assistance of the foreign countries in which they are located. Through participation in the planned 2,000 hours of spacecraft flight time this network will gain the know-how for a high level of efficiency in manned space flight.

6. The investment of \$225 million in the successful development and launching of the eight Tiros R&D weather satellites, and provision for three additional Tiros launches and the development and launching of the two more advanced Nimbus satellites, is providing the nation with the basic technology for an operational weather satellite system. Although obtained in a R&D program the Tiros weather data are now made available to more than 120 countries around the globe for operational use. In addition, the eighth Tiros satellite, now in orbit, carries a unique automatic picture transmission system which permits overseas units of our armed forces and any nation over which it passes to obtain directly from the satellite with a relatively simple ground station the pictures of the cloud cover overhead. To date nine countries and twelve military locations are taking advantage of this system.

7. An investment of \$115 million in Echo, Relay, and Syncom (along with the AT&T financed Telstar) has produced, in the very short period of four years, the scientific and engineering technology required for a world-wide communications satellite system. In something of a triumph for the marriage of policy and action, the Communications Satellite Corporation has been established to exploit this technology.

8. A family of unmanned space probes (Mariner and Ranger) has been developed to utilize the Atlas and Agena capability to go into orbit around the earth and escape so accurately toward the moon or the planets that a final mid-course maneuver enables the spacecraft to impact the moon or closely study Venus or Mars. This has given us, for an investment of \$1 billion, a capability to obtain scientific data from the moon and planets, and the interplanetary space outward from the earth to the planets. This sophisticated capability in space operations has benefited all of our programs, manned and unmanned, and provides a base line of knowledge and

technology which will undergird future generations of spacecraft. Further, the deep-space network, for an investment of about \$330 million, provides a capability for continuous communications with spacecraft at planetary distances. This investment includes the development of communications techniques whereby data can be received from distances of millions of miles, using only a few watts of transmitter power. This is a most important basic capability.

9. Twenty-four Explorer-Class scientific satellites have been launched into various types of orbits around the earth. They have mapped out many of the basic features of the ionosphere, the magnetosphere, and the area of interaction between the solar wind and the magnetosphere. The first Orbiting Solar Observatory, still in orbit after more than two years, has provided a great deal of information about the energy emitted by the sun and how this energy interacts with the earth's magnetosphere and the upper reaches of the earth's atmosphere. This ultimately will add greatly to our understanding of how this energy affects our weather. The data from these experiments have been augmented by about a hundred sounding rocket flights per year. Work has been proceeding on the Orbiting Geophysical Observatory and on the Orbiting Astronomical Observatory. The total being invested in all these efforts is \$1.2 billion.

In addition to developing the spacecraft, launch vehicles and ground support facilities to utilize scientific instruments in space, means have been developed to enable some 500 professors and their associated graduate students at about 100 universities to prepare and fly

experiments and thus participate directly in the program. This mechanism has brought the talent and judgment of some of the most creative people in the nation to bear on the understanding and use of space. Moreover, these people provide a transmission conduit through which the knowledge and understanding developed in the program is made available broadly throughout the country through prompt dissemination. This accomplishment is a major forward thrust in the theory and practice of the organization of large scale endeavors in science and technology. It has been made without losing the essential requirements for creativity of individuals and without doing violence to the established academic concepts and procedures on which scientific progress has rested in the past. This has involved an investment of \$280 million over the past five years.

Along with the scientific and industrial base, the facilities, the management system and the technological progress which have resulted from the nation's first years of effort in space have come significant advances in the methods employed in the conduct of research, through the marriage of science and engineering. An outstanding characteristic of space research is the fact that it has fostered a return to the concepts of exploratory science which produced such far-reaching advances during centuries of exploration here on earth. But the opportunity in space surpasses the exploratory science of the past, because man is attacking it with very advanced instruments and scientific methods.

While some of the specific technical and scientific advances resulting from space activity are more immediately obvious, many see its greatest impact in the more fundamental improvements in man's ability to conduct research. These include the new ways in which large-scale organized efforts are managed; the encouragement of multi-disciplinary effort not only among the scientific disciplines, but involving science and engineering; the new techniques and tools for the conduct of research, and the manner in which these are applied to the solution of age-old scientific and technical problems.

Advances in basic technology, and other specialized technology, have permitted the United States to move rapidly in the ballistic missile field through the solution of the reentry technique, in the development of high-speed aircraft for military and commercial purposes and in the development of strong capability in space. This has come about through a constant pervasive seeking out and wrestling with advanced theoretical problems by many men and women in NASA laboratories, in universities, and in research institutes. It has also been made possible by the marriage of advanced theoretical understanding with imaginative use of experimental procedures, wind tunnel tests, and flight tests of prototypes which are produced through the industrial base of the nation, usually under contract from the Government.

II.

This nation has thus quickly built the capacity to expand its aeronautical technology and to enter space. From the specific accomplishments to date, and those in reasonable prospect, the overriding reality is the emergence of means to explore space, this great new dimension of life, to learn from it and to use it in our national interest and for the benefit of all mankind. As to future missions or proposals for space objectives beyond those already approved, the September 1 report will consider them in the light of the overriding objective in both aeronautics and space: to foster, to persevere, to improve, and to make more effective the basic system above referred to.

It is essential that the nation constantly find better ways to spread our most difficult problems over the largest possible number of able minds, and to generate the kind of creative thought processes and translation of these into experimental procedures and systems which have led to the dramatic progress apparent in the matters outlined

above. The years immediately ahead will be years of intense activity, of expanded knowledge and broad operational capability. As we consider and approve new missions we must clearly maintain, through research and the development of technology, the ability and flexibility to do effectively whatever may be required of us. We must not lock the nation into costly development directed toward programs which may never materialize.

As we survey our present capacity and look to the future, a number of important objectives and missions appear to be emerging.

1. The Science of Space. Of major interest is the desire to understand our own planet, the space environment of which it is a part, and the control exercised over it by the sun. It is now known that our atmosphere does not end at some hundreds of miles as had been thought previously, but in the form of the radiation belts extends out to a distance of almost 50,000 miles on the sunward side, and possibly to several hundred thousand miles on the opposite side. Also, neither this region nor interplanetary space are quiescent voids, as previously conceived, but are regions of activity where radiation from the sun, the solar wind and its "frozen-in" magnetic fields, and the particles, magnetic fields and radiation ejected by solar storms, all play a vital role. The mechanisms whereby these sources of energy are generated by the sun, propagated through the interplanetary medium, and are absorbed in our atmosphere, are very poorly understood at the present time. Yet it is these very things that supply the energy for all life on earth, that determine our weather, and that affect significantly our ability to communicate over large distances on the earth. Not only are the solutions to these problems of great scientific interest in their own right, but only when they have been solved will accurate long-range weather forecasting be possible, will man's hope of controlling or modifying the weather be even remotely realizable, will the potential of global communications be fully utilized, and will man's ability to operate safely and reliably in space be possible.

From ground-based research it has been concluded: that stars condense from interstellar dust and that planets are probably formed simultaneously with their parent star; that at birth all stars must be very cool; and that the most massive ones rapidly increase in temperature until all but a small fraction of their emitted radiation lies in the ultraviolet wave lengths not accessible from the ground. Space astronomy will permit the observation of these stars at wave lengths where their radiated energy is the greatest, thus contributing to the understanding of the birth, evolution, and demise of stars and planets and to understanding of the universe, its present structure and the physical laws by which it is governed.

Exploration of the moon will significantly extend our knowledge, by answering such basic questions as: What is the moon's chemical composition, both in general and in detail; its mineralogical composition; are the radioactive isotopes of potassium, uranium and thorium concentrated at the surface; the distribution of mass throughout the moon; the absence of magnetic fields; seismic effects; the heat flow from the interior; and the age of the surface rocks as determined by the three important dating methods, the lead-lead, potassium-argon, and rubidium-strontium methods.

In this way, we can obtain knowledge as to the origin of the moon and, from this, new light will be shed on the origin of the earth as well as the rest of our solar system. Two basic theories for the origin of the moon are at present being put forth. The first of these assumes that the moon condensed into a solid body independently of the earth and was then captured by the earth after having been formed in some other part of the solar system. The second theory is that the moon was once a part of the earth and was later ejected from the earth.

In either case, a difference will exist in the structure of the moon depending upon its origin, and the absence of surface erosional effects on the moon's surface may have preserved on this body evidence of the solar system's early history that is no longer available to geologists on earth.

Detailed knowledge of lunar geology is of the utmost importance, because of the insight it may give into understanding the geology of the earth.

Exploration of the planets presents the possibility of discovering new life forms. In addition, photographing the planets at close range, the making of measurements of their atmospheres, magnetic and gravitational fields, and radiation belts, and determining their surface and subsurface characteristics, would all be of significant scientific value. Furthermore, there is a strong possibility, particularly in the case of Mars and Jupiter, of finding effects of the sun on the other planets which will enable us better to understand those on the earth - Mars because it has an environment most closely resembling that of Earth, and Jupiter because of the great radiation belts that are believed to encompass it.

The scientific importance of detailed study of the near planets and the effect that such investigations would have in dramatizing the scientific and technological skill of the nation that provides this information has been demonstrated by the interest generated by our Venus Mariner flight. The importance of such planetary exploration also explains the continuing large scale effort of Soviet Russia in the many flights they have attempted to Mars and Venus.

Landing of an instrumented payload on the Martian surface would be an important step in unraveling the long-term history and evolution of the solar system. The first efforts would be concentrated on Mars, primarily because

of the possibility of the existence of life there. It is possible that the Martian atmosphere, in the planet's earlier stage of development, contained a great deal more water vapor than at present. If temperature conditions were favorable, lakes and rivers might have existed, and the sedimentary history of this area might well be preserved in the Martian rocks. At present, it is believed that violent dust storms exist, so that more recent history may be recorded in aeolian sedimentary sections. The seasonal variations of the planet are also of great interest to the bioscientist because of the changes in surface coloration that have been observed.

In addition to providing a means for a better understanding of the solar system and of the earth as a part of it, and of the possibility of existence of life elsewhere in space, the space program also provides biologists with an excellent opportunity to study the fundamental processes of living organisms. The availability of space-borne systems which permit transportation of biological specimens beyond the range of terrestrial influences makes it possible to study the effects of earth environmental parameters on the fundamental processes of living organisms and systems. Since the adaptation to environment, either by genetic or physiological processes, constitutes one, if not the principal, characteristic of living material, this provides a method of running a series of critical experiments in areas of genetics, evolution, homeostasis and physiology, and for uniquely testing basic biological theories and hypotheses.

2. Research and Technology. To lay the scientific and technological groundwork for future missions and to assure this country's future capabilities and pre-eminence in space flight and aeronautics, a vigorous research and technology development program must be maintained. Such research work in years past formed the basis for our present aeronautic and space capabilities and for our presently approved missions.

A substantial part of our research and technology effort in the future will be directed toward a continued upgrading of the nation's overall capabilities for manned operations in space. This work will look toward future manned vehicles which will have more conventional take-off and landing characteristics and a maneuvering capability for inspection and reconnaissance; toward manned space laboratories that would utilize man's capabilities for direct observation and manipulation and thus provide unique opportunities for conducting research in many fields such as astronomy, biology, botany, medicine, meteorology, communications, and navigation; toward manned space stations that may be needed as staging, repair, checkout and assembly bases for future space operations; and toward manned vehicles which ultimately can orbit and land on the planets.

The type of research likely to be pursued will include investigation of new concepts and improved versions of systems for propulsion of aircraft and space vehicles, for generation of electric power, for support and protection of man during long trip times in space, for communication between the earth and the spacecraft, and for collection and transmission of data gathered by space vehicles millions of miles away from earth. Research on electronic components and equipment that will operate reliably for long periods of time will also be included, as will further developments of vehicle structures and materials and further investigations of the effects of the space environment (space radiation, meteoroids, vacuum, zero gravity, and wide ranges of operating temperature) on design, performance, and operation of space vehicles.

To assure this nation of the propulsion and launch vehicle capability for effectively handling various types of space missions to be undertaken within the next several years, and to realize the maximum payload capabilities of the launch vehicles presently being developed, a part of NASA's

future work will be directed toward further improvement and development of propulsion systems and launch vehicles. Likely to be included in these efforts will be continued improvements of the present types of chemical propulsion systems as used in vehicles such as Atlas, Saturn, and Thor; continued development of hydrogen-oxygen and other high-energy, high-performance systems; and the development of some additional escape stages for launch vehicles such as Saturn IB or Titan III.

Attention will also be given to continued research on toroidal ring and other advanced engine designs, and new rocket propulsion concepts such as nuclear rockets and electric propulsion which may lead to very large improvements in future rocket performance. The latter are highly desirable for manned planetary missions, extended lunar exploration which may involve the establishment of extensive facilities on the lunar surface, as well as unmanned missions to the distant planets and probes out of the plane of the planetary orbits.

In addition to rocket propulsion, research and technology work to assure the availability of more powerful air-breathing engines, such as those needed for supersonic and hypersonic aircraft or recoverable launch vehicles, will be undertaken as the needs develop.

Aeronautical and space systems require continually increasing amounts of on-board electric power as their size, performance, flight distance, and number of experiments increase. Future work on electrical power supplies utilizing chemical, solar, and nuclear sources will be directed toward providing longer life, increased reliability and higher capacity. Electrical power generating methods, which will be studied to determine which are most advantageous for various needs, will include large-area solar cell arrays; radioisotope powered systems for long-time applications where dependence on the sun is not possible; chemical batteries and fuel cell systems for use individually as

short-duration power sources or in combination with long-life power sources; engines that generate electric power by utilizing the hydrogen and oxygen carried in the main propellant tanks for emergency or short-duration portable power plants; and nuclear reactor powered systems to provide the kilowatt to megawatt powers needed for manned space laboratories and extra-terrestrial bases as well as to provide power needed for electrical propulsion systems.

Another important part of our work in the advanced technology programs will be concerned with electronics and with the many vital check-out, control, communications, and long-distance data transmission systems which depend so heavily upon electronic techniques. Many of the electronic systems and components upon which our present space systems are necessarily based, have been designed without sufficient attention to the rigid requirements for long-term reliable operations in space. The new NASA Electronics Research Center and the research programs it will generate throughout the nation, will put many able minds to work on developing whole new concepts and engineering solutions to problems in the electronic field and give us the technology through which reliability can be substantially increased.

Along with concern for propulsion and other systems needed for placing men and scientific instruments far out into space, we must also look toward advances in electronic technology which will enable us to maintain reliable two-way communication and to transmit back to earth the large volumes of observational, photographic and scientific data which will be collected. Promising avenues for future upgrading of our technology in these areas include light-beam (laser) communication systems, higher capacity digital data handling and computing systems, and large ground antenna arrays.

Theoretical and experimental research will also be continued on materials used in the construction of high speed aircraft, spacecraft, and rockets. Future programs will be aimed at developing materials and structures which will stand up under very high and very low temperatures, bombardment by micrometeorites, and radiation.

In future years, exploitation of our capabilities for manned space flight may require man to operate within the confines of a spaceship for longer and longer periods of time. Consequently, we will be concerned with the development of life-support technology such as the provision for water and oxygen, the elimination of poisonous trace gases, and the disposal or reclamation of body wastes. Although life-support elements can be provided for some near-earth missions by resupply systems, some longer-range missions may require that life-support be provided in a closed loop system to permit accomplishment of the mission with reasonable vehicle and spacecraft sizes.

Methods of protecting man by providing near-normal temperature and atmosphere, and other life-sustaining elements, also involve a detailed understanding of man's capabilities, his endurance to stress, the contaminants that may develop in the high vacuum environment of space in confined quarters, and a better general understanding of man's physiological and psychological reaction to a spacecraft environment.

Future NASA activities in aeronautics will continue the work of providing the technology and understanding of flight through the atmosphere under various speed and range conditions required for both civilian and military uses. Active work now under way on vertical and short take-off aircraft systems and on the propulsion and airframe and flight environment of the supersonic transport will likely be followed by a future extension into propulsion, control, and flight problems of hypersonic transports which may become the basis for efficient global

transportation systems. This fundamental aeronautical research effort in materials, structures, aerodynamics and propulsion will be continued at a high level to provide for the nation's future aeronautical developments.

III.

Listed below are several possible missions in the broad areas of earth orbital operations, lunar exploration, and exploration of the planets and interplanetary space. These represent the broad areas toward which the nation's future efforts might be directed. By September 1, we will have evaluated these and other possible future space undertakings to determine those that appear best to serve the national interest in the next decade or two.

Earth Orbital Operations

A program could be undertaken to coordinate and focus the various suggested earth orbital projects through a concerted effort directed toward understanding the behavior of the sun and of its influence on the space and earth environments, by means of advanced solar observatories and a coordinated use of geophysical observatories and interplanetary probes. This program could also involve the use of man's ability to carry out complex scientific and technological space experiments, by means of a manned space laboratory that would be able to remain in orbit for extended periods of time so that these capabilities could be evaluated. Such an effort would, of course, provide knowledge and experience for manned flight which could be used for military purposes, should this become necessary.

An integral, yet distinct, part of the investigations noted above is research and development leading to operational meteorological, communications, and navigation satellite

systems. Developments in meteorological satellites can add materially to our knowledge of the state of the atmosphere, its motions and its climate, and to our global coverage of weather phenomena in order to provide a basis for accurate long-range weather forecasting. Technological satellites would enable advanced stabilization and control techniques to be investigated, new approaches to such problems as air traffic control and increase in traffic capacity of air lanes to be pursued, and the feasibility of direct radio and television broadcasting to all parts of the globe to be determined.

Presently approved missions and others under consideration in the above areas are:

A. Unmanned Scientific Missions

1. Investigations of the Sun, the Space Environment, and their Interrelationship
 - a. Orbiting solar observatories carrying telescopes and other instruments above the atmosphere to study the electromagnetic radiation from the sun.
 - b. Earth satellites to study specific phenomena such as the influence of the sun on the earth's atmosphere, the particle trapping mechanism and the interaction of the solar wind and the earth's magnetic field.
 - c. Interplanetary probes to study the particulate radiation from the sun, to determine the solar atmosphere, and to investigate the space environment.

2. Astronomical Investigations

Orbiting astronomical observatories to study the electromagnetic radiation emitted by the stars and galaxies from above the absorbing and disturbing influence of the atmosphere.

3. Biological Investigations

Recoverable satellites carrying animal and plant life to study the effect of the space environment, or the absence of terrestrial effects, on living organisms; and specially instrumented probes to search for evidence of extra-terrestrial life forms in meteorites and asteroids.

B. Manned Operations

1. Spacecraft to orbit two men for periods up to two weeks to extend the knowledge of problems associated with long duration flight, and to develop procedures and operational techniques for rendezvous in space. (The approved Gemini program.)
2. Spacecraft to orbit three men for periods up to two weeks to further extend knowledge of man's capabilities in space and to develop the rendezvous, docking and other flight operations necessary to carry out the manned lunar mission. (The approved Apollo program.)
3. Spacecraft to orbit two men for a period of 30 days to investigate the potential of earth-orbital flight for future military operations. (The approved Air Force Gemini/Manned Orbiting Laboratory program.)

4. Spacecraft to orbit two men for periods up to 90 days to obtain fundamental knowledge on the performance of man in longer duration space missions, to accomplish manned scientific and engineering research tasks, and to develop the spacecraft capability for longer duration lunar missions and for logistics resupply of possible earth orbital laboratories. (Four contracted studies are presently underway and related in-house work is being conducted by NASA to establish a basis for a project decision.)
5. Orbital manned laboratories:
 - a. Laboratories capable of sustaining three to eight men and of operating for periods up to 1-3 years with appropriate logistics resupply in order to utilize man's abilities to observe, to reason, and to perform complex tasks, such as: to conduct a wide variety of research activities, to develop operational capabilities in earth orbit, to develop and qualify subsystems and systems applicable to lunar and planetary missions, and to establish the feasibility of manned missions of sufficient duration as would be required to accomplish planetary exploration.
 - b. Large laboratories or semi-permanent space stations, capable of sustaining up to 24 men, as major installations in space to accomplish to a greater degree the objectives of the smaller laboratories, with potential for serving as supporting facilities for planetary missions.

- c. Manned laboratories in synchronous orbit for the primary purpose of enabling continuous manned observation of major portions of earth.

(Nine contracted studies by NASA and four by DOD are underway and will augment extensive in-house studies of manned orbiting laboratory configurations and missions.)

C. Applications of Space Flight Technology

1. Meteorological Satellites

- a. Spin-stabilized satellites for developing the technology needed for photographing cloud cover and making temperature measurements over large areas of the earth's atmosphere. The developments are intended for inclusion in operational meteorological satellite systems. (The approved Tiros program.)
- b. Continuously earth-oriented spacecraft, incorporating TV cameras, infrared and other optical and microwave sensors, to obtain improved cloud-cover pictures and nighttime coverage, and more extensive measurements of the radiant energy emitted, reflected, and absorbed by the earth and its atmosphere. (The approved Nimbus program.)
- c. Extension of the Nimbus capabilities incorporating improved sensors, cameras, control, and data systems to permit remote measurement and readout of atmospheric data at several altitudes over the entire globe several times a day.

- d. Spacecraft orbiting at synchronous altitude to develop a capability for continuously viewing fixed areas of the earth in order to continuously monitor transient weather phenomena such as thunderstorms, fronts, or squall lines.

2. Communications and Navigation Satellites

- a. Communications satellites to develop the unique capabilities of satellites for world-wide communications. (The approved Echo, Relay and Syncom programs.)
- b. Advanced satellites to develop the technology needed to transmit from satellites directly to small land and airborne receiving sites equipped with simple, economical antennas. Development of this technology could lead to systems for the control and coordination of air traffic in congested trans-ocean air lanes, for all-weather global navigation and position fixing; and for direct radio and television broadcasting from satellites to home receivers.

Lunar Exploration

The Apollo program will indicate the feasibility of carrying out a more extensive lunar exploration program capitalizing on the investment already made in facilities, trained manpower, the industrial base and university support and the operational experience. This could lead to a logistic system which would provide a shelter, life-support system and a roving vehicle for the astronauts to enable them to extend their stay-time to two weeks and to explore

selected areas of the lunar surface within several miles of the landing site. Subsequently this system could be expanded to permit the establishment of a more permanent lunar base for extensive exploration and detailed scientific investigation, if this proves desirable.

The range of missions either in progress or under consideration is indicated as follows:

- A. Probes to take close-up pictures of small, selected areas of the lunar surface up to the time of impact. (The approved Ranger program.)
- B. Probes to orbit the moon and perform a high resolution mapping survey of large areas of the surface. (The approved Lunar-Orbiter program.)
- C. Probes to soft land TV cameras and scientific instruments on the moon to determine the surface structure and composition. (The approved Surveyor program.)
- D. Spacecraft to place three men in orbit around the moon, land two on the lunar surface, conduct limited lunar exploration, and return to earth for the prime purpose of developing the technology, facilities, industrial base, and the trained manpower for manned operations in space; and to obtain additional scientific knowledge about the moon and its environment. (The approved Apollo program.)
- E. Manned exploration of the lunar surface for periods of approximately two weeks or more utilizing a logistics system to provide the necessary shelter, life support, and roving vehicles to enable scientific studies of selected areas within a range of several miles from the landing point. (Ten contracted studies are supporting the present NASA in-house effort to define these systems in considerable depth.)

- F. Establishment of semi-permanent lunar stations to conduct extensive scientific investigation of larger areas on the moon through the development and utilization of larger logistics systems. (Six contracted studies of an exploratory nature are presently underway to examine possible concepts for the major system elements of these stations.)
- G. Establishment of permanent lunar bases for the exploitation of lunar resources, for staging of deep space missions, or as major scientific observation sites. (Preliminary study effort is underway in this area. More detailed study is contingent upon obtaining information on the lunar surface and experience with lunar flight systems.)

Planetary Exploration

Knowledge of the nearby planets Mars and Venus, resulting from the present fly-by Mariner program, is limited because the measurements are still being made at a great distance from the planet (22,000 miles in the case of the '62 Mariner probe past Venus). This knowledge may be increased many-fold by landing a sizeable payload module on the surface. Such a module could determine the structure and composition of the planetary atmosphere during entry as well as provide television photographs of the planet and scientific information about its surface and subsurface composition and characteristics. Of foremost national, as well as scientific, interest is the possibility of including substantial experiments for the detection of life on the planet. However, such instrumented observations may prove inconclusive since it is difficult to design for all the various possible life forms, particularly so in the event that advanced forms exist.

Man's talents and capabilities would prove invaluable under these circumstances, as well as for carrying out geological investigations, since this too is largely an observational science. Before manned planetary missions can be embarked upon, however, much must be learned about the nature of the planets and interplanetary space, significant advances must be made in propulsion, space power and communications systems, extensive spacecraft operational experience must be acquired, and information is needed about man's performance capabilities over the long flight periods required and about the spacecraft systems needed to support and protect him.

Exploration of the distant planets, of comets and of the asteroids would complete the initial investigation of the solar system, although significant propulsion and space power advances are required for the accomplishment of even fly-by missions of these types.

Specific planetary missions that are currently planned and those that are under consideration are as follows:

A. Mars-Venus Exploration

1. Spacecraft which fly-by the planet with instruments to determine temperatures of the surface and the atmosphere; to obtain information about the atmosphere to aid in the design of vehicles to enter the atmosphere and land; to look for evidence of extra-terrestrial life; to look for magnetic fields, ionosphere and radiation belts. (The approved Mariner program.)
2. Spacecraft which fly-by the planet and send an entry vehicle into the atmosphere to more accurately determine the characteristics of the atmosphere. (Three studies are currently underway.)

3. Spacecraft to orbit the planet and land a capsule on the surface to begin the systematic study of the properties of the atmosphere, ionosphere and magnetosphere of the planet and to search for extra-terrestrial life. (The evaluation of three completed studies and one now underway will aid in a decision regarding the most promising space system to fulfill this mission.)
4. Spacecraft to land an automated biological laboratory to study the biological systems on the planet, to study the effect of the planetary environment on terrestrial biology and to provide significant information needed to design spacecraft for a manned landing on the planet. (A study of the functions to be performed by the laboratory is now commencing. This will lead to a description of the overall space mission and system characteristics related to placing such a laboratory on Mars.)
5. Manned missions to Mars and Venus such as the following:
 - a. Manned fly-by missions of Mars and Venus to obtain additional fundamental knowledge of the interplanetary environment, the planetary atmospheres, and the planetary surfaces through the use of manned observations and data gathering, as well as unmanned probes and landers carried on board the manned spacecraft.
 - b. Manned landing missions to Mars in order to obtain scientific knowledge of the atmospheric, surface, and subsurface characteristics of the planet, and to accomplish a major goal in man's conquest of outer space.

- c. Manned orbiting missions of Venus, and, if possible, land on the surface for the purpose of obtaining scientific knowledge of the planet.

(Six contracted studies are underway, in addition to internal NASA studies, to explore the feasibility of these manned missions and to focus the longer-range research and development activities of the agency.)

B. Exploration of the distant planets, asteroids and comets:

1. Spacecraft which fly-by Jupiter to study the magnetic fields and trapped radiation belts believed to be responsible for the radio noise from Jupiter.
2. Spacecraft to orbit Jupiter to map the magnetosphere, determine structure, composition and temperature of the atmosphere.
3. Spacecraft to fly-by Mercury to determine the surface characteristics and measure the surface temperature.
4. Spacecraft to fly-by asteroids to ascertain the nature and surface characteristics of the asteroids to attempt to determine whether they are the remains of a planet or have another origin.
5. Spacecraft to fly through the tail of a comet to determine the composition of a comet, its origin and the physical laws which govern cometary behavior.

(The spacecraft mission requirements for accomplishment of these missions are so interrelated that a single broad study encompassing all of these missions has been undertaken. This study, which is nearing completion will aid in determining technological feasibility and assessing the value of scientific information which might be obtained.)

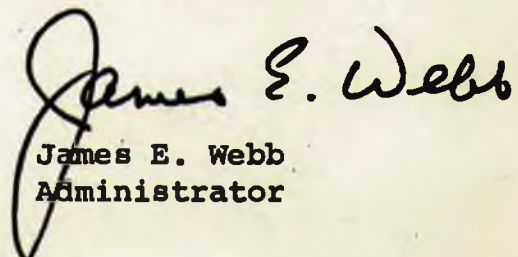
IV.

An extensive analysis of each mission listed above is being made to determine its requirements in manpower, facilities, and other resources and to balance these against the value of potential returns in the form of new national space capabilities, new knowledge, new civilian and military applications and new industrial capabilities.

Particular attention is being paid to maximizing the use of major technological developments in propulsion and elements of flight hardware already in hand or underway and the identification of alternative methods of carrying out these missions. At the same time a significant part of the study effort is going into the identification of new advances in technology, flight hardware, and operational techniques necessary for the continual upgrading of the nation's research and operational space capabilities.

By September 1, our studies will have progressed to a point such that decisions can be made regarding what combinations of the above missions will be most effective for current national needs and which will allow maximum flexibility for changing future needs.

Respectfully yours,



James E. Webb
Administrator



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON 25, D.C.

EXECUTIVE
051

The White House
Washington

OFFICE OF THE ADMINISTRATOR

February 6, 1964

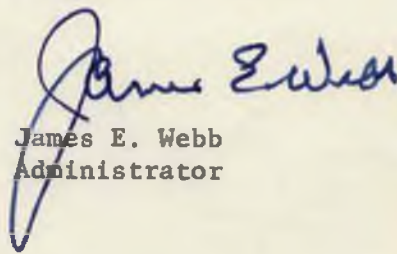
The President
The White House
Washington 25, D. C.

Dear Mr. President:

We have initiated a review of the future program plans of NASA, in accordance with your letter of January 30, in which you indicate the necessity of relating current development work with well defined missions.

A preliminary report will be in your hands by May 1, and the final report by September 1, 1964.

Respectfully yours,


James E. Webb
Administrator

NATIONAL AERONAUTICS and SPACE COUNCIL

February 14, 1964

May 22, 1964

Noted and returned to White
House Central Files.


E. C. Welsh

RECEIVED
FEB 14 1964
CENTRAL FILES

Checked by Kardes

EXECUTIVE

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FG260

January 30, 1964

Dear Jim:

(James E. Webb, NASA)

Reflecting on our recent decision as to the 1965 budget level of the Rover program, I am concerned that we be in a better position to make future decisions involving this and other large space programs.

As you will recall, the principal argument against continuation of the NERVA development was the difficulty in defining missions for this rocket system which could not be performed by other systems whose development is much more advanced. Therefore, it seems important that in the next few months -- before we must face new decisions -- we review our future space exploration plans with the object of relating hardware and development programs to prospective missions.

Since space undertakings beyond Apollo will be complex, costly and difficult, such a review should include at least the following actions:

1) A statement of possible space objectives beyond those already approved. The views of the scientific community as reflected, for example, by the Space Science Board of the National Academy of Sciences, should be obtained to help define the most important aims and missions for scientific purposes.

2) The planned research and development programs of your agency should be reviewed in relation to these aims. The projection should include an analysis of the advances in space technology likely to be needed as well as estimates of the time and funds required to implement the major missions of the over-all program.

Sent - 2/1/64

Copy to Dr. Horning - 2/1/64.

RECEIVED

FEB 5 1964

CENTRAL FILES

Page 2

3) The research and development programs currently underway, whether sponsored by DOD or your agency, should be reviewed in the light of (1) and (2) above. In particular, alternate booster arrangements should be considered. I am interested in learning about the extent to which our needs of the next decade can be met by boosters already under development.

I would like for you to explore these and other steps and make a preliminary progress report about May 1st and a final report not later than September 1, 1964.

Sincerely,

Lyndon B. Johnson

Honorable James E. Webb, Administrator
National Aeronautics and Space Administration
Washington, D. C.

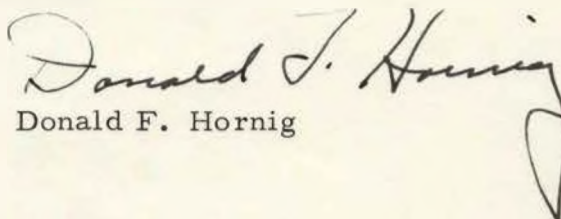
THE WHITE HOUSE
WASHINGTON

January 29, 1964

MEMORANDUM FOR
THE PRESIDENT

It is my understanding that at the time of the budget decision on the Rover (nuclear rocket program) you requested that Dr. Wiesner draft a letter to Mr. Webb requesting information which would put future budget reviews on a sounder footing.

A suggested draft is attached.


Donald F. Hornig

Attachment

DRAFT
1/25/64

Dear Jim:

Walt
Adm.
NASA

Reflecting on our recent decision as to the 1965 budget level of the Rover program, I am concerned that we be in a better position to make future decisions involving this and other large space programs. ^PAs you will recall, the principal argument against continuation of the NERVA development was the difficulty in defining missions for this rocket system which could not be performed by other systems whose development is much more advanced. Therefore, it seems important that in the next few months, ~~and~~ before we must face new decisions, we review our future space exploration plans with the object of relating hardware and development programs to prospective missions.

Since space undertakings beyond Apollo will be complex, costly and difficult, ~~I think it desirable that~~ such a review ^{should include at least the} ~~include, among others, the~~ following actions:

- 1) A statement of possible space objectives beyond those already approved. The views of the scientific community as reflected, for example, by the Space Science Board of the National Academy of Sciences, should be obtained to help define the most important aims and missions for scientific purposes.
- 2) The planned research and development programs of your agency should be reviewed in relation to these aims. The projection should include an analysis of the advances in space technology likely to be needed as well as estimates of the time and funds required to implement the major missions of the

of the over-all program.

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steps and make a

SUMMARY REPORT FUTURE PROGRAMS TASK GROUP

JANUARY 1965

NASA



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

SUMMARY REPORT FUTURE PROGRAMS TASK GROUP

JANUARY 1965



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON, D. C. 20546

FOREWORD

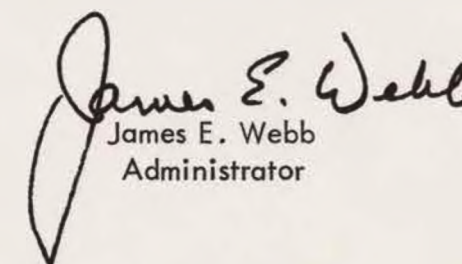
This summary report of the Future Programs Task Group, directed by Francis B. Smith of Langley Research Center, presents the results of studies made during 1964 to answer inquiries made by President Johnson as to criteria and priorities for space missions to follow those now approved for the decade of the 1960's.

The President's request was for a review of space objectives in relation both to what we have learned from our space efforts and to the most important emerging concepts of missions needed for scientific purposes and for advances in technology. The President requested that our evaluation be made in relation to estimates of time and funds required to complete programs already approved and under way.

The Future Programs Task Group was established to develop materials to meet the President's request. It has studied: (1) the capability being created in the present aeronautical and space effort; (2) next-step or intermediate space missions that could use or extend this capability; and (3) a number of long-range missions which deserve serious attention. This summary report, resulting from these studies, provides a source of information on accomplishments to date and indicates the general time periods within which we can assume or forecast the availability of further scientific and technical knowledge. It is, in addition to providing a review for the President, a timely and valuable working document for use within NASA and other agencies as a foundation for further analysis and discussion looking toward decisions that can be based on a broad consensus as to values and timing.

A major concern of the Task Group has been to identify the areas and levels of technology required to accomplish the most likely future missions and to provide a basis for informed decisions relating to the allocation of resources and timing for those which may be approved. Considerable attention has been given to steps we need to take to insure that these areas and levels of technology are available as needed.

The long range developments section of this report contains a discussion of the technology development programs which are under way in NASA, and a number which should be given careful consideration in making future plans. Many of these programs are broadly based, but are also essential to provide optional means to accomplish the missions under study and also provide a strong basis for judgments bearing on the value, time and cost elements.


James E. Webb
Administrator

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I. INTRODUCTION

The successful flight of Sputnik I, in its most fundamental aspect, meant that man had taken the first step toward the exploration of a new environment by means of a new technology. It also meant that in the USSR, which accomplished this first step, new horizons were opened and there was a surge of national pride and accomplishment. An internal drive was created that changed the posture of Soviet society and lifted it above many of the frictions and tensions of the existing status. Horizons were widened. Internationally, the leadership and image of the Soviet Union were vastly enhanced. The flights of Gagarin and other Soviet Cosmonauts added impetus to a marked degree.

In the United States and in the Free World, as we all know, the immediate effects were quite the opposite. However, since then, we have made tremendous progress under a broad based and balanced program aimed at achieving pre-eminence in aeronautics and space.

Down through the course of history, the mastery of a new environment, or of a major new technology, or of the combination of the two as we now see in space, has had profound effects on the future of nations; on their relative strength and security; on the relations with one another; on their internal economic, social and political affairs; and on the concepts of reality held by their people. From the elements of each such new situation which history records, all or most of the developments listed in Figure 1 have materialized.

The long-range effects of man's entry into space, in person and by instruments and machines, can be best forecast in terms of these considerations. As a new environment, space may well become as important to national security and national development as the land, the oceans and the atmosphere; rockets and spacecraft as important as automobiles, trucks, trains, ships, submarines and aircraft. The foreseeable returns from scientific advances, technical advances, and practical uses compare favorably with the returns yielded by the most vigorous past periods of exploration of newly opened segments of man's expanding frontier.



Fig. 1

If these larger considerations of the space effort are to be adequately dealt with in terms of national policy, they must be translated into broad objectives in order that particular programs and missions can be defined and evaluated. For the United States, these objectives relate aeronautics to space and are contained in the Space Act of 1958. They are outlined in Figure 2.

Under the Space Act, NASA bears the general responsibility for continuously providing an adequate underlying aeronautical and space capability and cooperating with the military services and other agencies which have, or anticipate, specific missions and uses. In 1958, and again in 1961, two major periods of wide debate and assessment brought decisions to undertake missions and programs which accelerated our progress toward the achievement of these objectives. The capability which has been created through the work thus begun and now under way will be the basis for this analysis.

First, however, we need to understand that we face certain conditions and constraints.

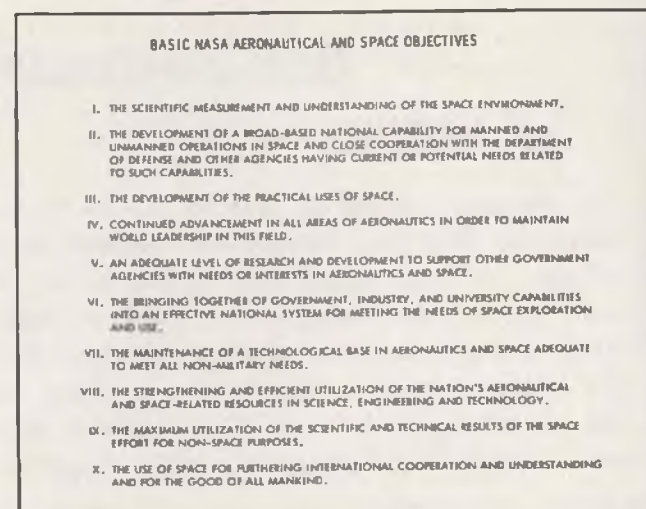


Fig. 2

II. SUMMARY OF CONDITIONS AND CONSTRAINTS FOR FUTURE PLANNING

In planning future missions in space, there are a number of conditions and constraints which must be considered. These are:

- a. The space activity of the Soviet Union indicates a vigorous program in near-Earth, lunar, planetary, and manned space fields. The Soviet announced program is still broader, and extends to communications and meteorology. The Russians have exploited their initial advantage in launch vehicle power, have upgraded that power, and have shown great skill in exercising their systems. The United States must, of course, meet its own needs in space rather than accept the judgment of another nation. We must decide the pace at which our needs will be met. Our decisions must be related to other national needs and priorities and we must recognize that at this early stage in space exploration the full meaning of space cannot be forecast. Still, Soviet actions must be taken into account as indicating values that they see and seek. Their skill in exploiting space spectacles to their advantage in the areas of national prestige and international politics must be recognized and countered. At a minimum, the United States must achieve a basic knowledge of space environments and systems, and must maintain an operational capability sufficient to guarantee full access to and use of space.
- b. As a result of the work of the past 6 years, we already have a broad base of scientific and technical knowledge about many factors of space and are entering a period of rapidly expanding launch capability which we will use to achieve a far broader scientific and technical base and to gain wide experience in manned space flight. Our seven successful Saturn I test launches point to the operational use of the much greater boost power of the Saturn IB by 1966 and to the use of the giant Saturn V booster by 1967. The Defense Department's Titan III-C booster is expected to begin flight testing in the near future. The application of Centaur as an upper stage can augment considerably the capabilities of the larger vehicles.

In the critical area of determining man's capabilities in space, Gemini operations with two-man crews, supported by a world-wide net of stations and recovery forces and managed from our new mission control center at Houston, will begin in 1965. Hundreds of man hours of flight experience with mission durations up to 14 days will provide experience in rendezvous, docking, manned performance outside the spacecraft and other operations, adding large increments to our knowledge. Apollo operations with three-man crews beginning in 1967 will significantly extend the Gemini experience so that by the time we undertake the first manned landing on the Moon, the Gemini and Apollo programs will have provided thousands of man hours of flight time. Additional general and specialized manned flight experience is expected from the Manned Orbiting Laboratory (MOL) under development by the Department of Defense.

In science, the measurements and knowledge acquired over the next few years will become increasingly valuable as they are used and refined. More sophisticated questions will be asked by scientists and more sophisticated spacecraft, such as the Orbiting Astronomical Observatory (OAO) and the Surveyor, together with manned

spacecraft, will be used to search for answers.

In communications and meteorology, the imminent operational use of satellite systems will answer many questions as to the current value of these systems. Further research will answer many questions as to their potential for the future.

These activities will uncover new uses of space, force the solution of many emerging technical problems, and reveal others not now identified. This has been the way of all new areas of scientific and technical development, and it will certainly be true in space.

It is, therefore, essential that in making plans for the future all elements required for a balanced program and the practice of maintaining maximum flexibility be preserved.

- c. The United States decided in 1958, and reaffirmed the decision in 1961, to move rapidly in all areas of space exploration. The wide range of power in the boosters in our National Launch Vehicle Program and the wide scope of completed and on-going missions reflects this fundamental decision. Our missions extend from sounding rocket exploration of the near-Earth atmosphere; to orbiting solar, geophysical and astronomical observatories; to manned exploration of the Moon; and to probes out to Venus and Mars. New capabilities, both in science and in the practical uses of space, have been developed and these capabilities are being rapidly expanded.

As we emerge from this initial period of space exploration, we can see that our 1958 decision to mount a broad, balanced program was a wise one. The scientific and technical returns to date clearly indicate the value of continuing within this framework. In areas where a definitive point has not yet been reached, as in manned flight, we face the urgent need to push forward to such a point.

- d. Of major importance to future planning is the fact that, in NASA, approved programs are making heavy demands on limited financial and human resources. At present budget levels, this situation will continue for at least another year. Manned flights of Gemini will begin shortly; the Saturn IB must be completed and mated to the Apollo spacecraft for manned flights in earth orbit; the Saturn V must be brought along and everything possible done to achieve a manned lunar mission in this decade. In addition, both the Lunar Orbiter and Surveyor programs must be pushed vigorously and in proper relation to the Apollo requirements in design, production and flight.

Unless the NASA budget is to be increased, the present situation requires that priority be given in the near-term period to insuring that these programs proceed without delay, under vigorous budgetary control, and produce successful results. As this is accomplished, we can, within present budgetary levels, begin to make plans to move toward other large goals in space and undertake new missions. The Saturn IB/Centaur booster can provide the power for a large Voyager mission to Mars by 1971. The Apollo system will gain in reliability through repeated use over the next several years and will then provide much of the launch and spacecraft capability to meet expanded goals.

Therefore, unless an urgent National need arises, large new mission commitments can, better than in previous periods, be deferred for further study and analysis based

heavily on ongoing advanced technological developments and flight experience.

- e. During the past 6 years, the United States, in addition to carrying out many specific missions, has been engaged in creating a large, basic space capability. This includes a versatile family of launch vehicles and spacecraft, and the trained manpower and facilities to continue to produce and use them. Other things being equal, these capabilities, with the resultant gain in reliability, should be used to the maximum degree in future missions. If such capabilities are not used they deteriorate. Their use can achieve lower costs and greater assurance of success for many desirable future programs than can otherwise be achieved.

In summary, the NASA manned program for the future, and the developments leading toward it, illustrated schematically in Figure 3, require that we must:

First, apply available resources to every aspect required for success in the on-going programs, especially the Apollo program, and to bring these to fruition as quickly and efficiently as possible.

Second, define an intermediate group of missions and work toward them using the capability being created in the on-going programs.

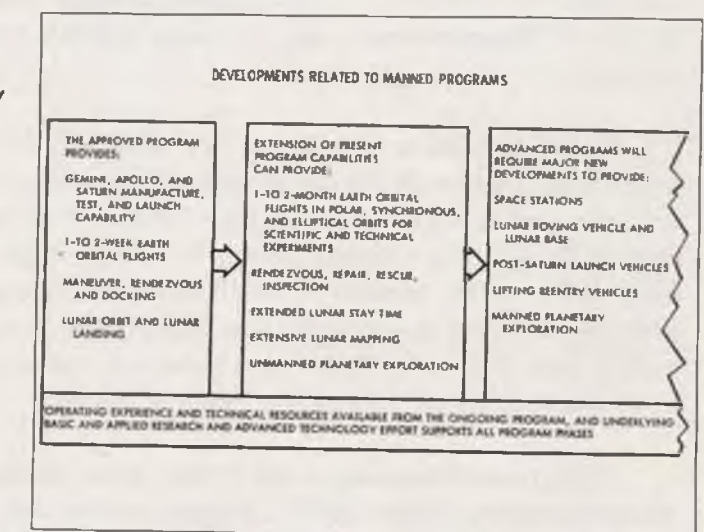


Fig. 3

The launch vehicles and spacecraft being developed in the Apollo program are of such size, versatility and efficiency as to be of decisive importance in achieving and maintaining pre-eminence in space during the next period. Significant use of this capability over and above the presently programmed Apollo mission can be made as early as Calendar Year 1968, if small increments of additional resources are committed soon.

As now planned, by 1969 the Apollo program will build up to a capability to launch six Saturn IB systems and six Saturn V systems annually. The Saturn IB will boost 35,000 pounds or more to Earth orbit and, when mated to the Centaur, can send up to 10,000 pounds of unmanned payload to Mars, of which up to 5,000 pounds can be landed on the planet. The Saturn V will place 250,000 pounds or more in Earth orbit or send 95,000 pounds to the vicinity of the Moon. These powerful boosters, in these numbers, will make it possible for the first time for this Nation to regularly launch large payloads in operational space systems for a wide variety of purposes, in manned and unmanned flights in the Earth-Moon region, and for unmanned planetary missions.

Further, the present program will provide the industrial base and operational capability for producing and using eight Apollo-LEM spacecraft systems annually. A broad spectrum of manned space flight missions can be carried out with these systems. In near-Earth space, missions can include low inclination, polar, or synchronous orbits to accomplish scientific, technological, and applications objectives. Such missions can utilize extensive maneuvering

and extra-vehicular operations. Such flexible multi-purpose use of the Apollo-LEM system can be accomplished by reduction of crew size and utilization of payload margins either for expendable supplies or propellants. It is entirely feasible to extend the manned Earth orbital stay time of the Apollo-LEM system to 30 days and possibly to as much as 90 days. Similarly, the Apollo-LEM system capability for lunar missions can be extended to permit detailed mapping of the Moon from lunar polar orbit; and the Lunar Excursion Module can be used as a truck to provide supplies for longer stay time and increased exploration capability on the lunar surface.

For unmanned planetary exploration, the Saturn IB, using the Centaur as a third stage, can not only launch a 10,000-pound Voyager spacecraft with a 5,000-pound lander to Mars for the 1971 opportunity, but can meet the increased volume and power requirements for later years.

If one or more such missions are selected, intensive study should begin immediately and preparations be made for undertaking firm commitments for procurement of additional launch vehicles and spacecraft about July 1966. Program definition of the Saturn IB-Centaur mating should begin immediately, but major flight hardware expenditures need not begin until 1966. With respect to modification of spacecraft life support and power systems for extended manned operations, the fabrication of components required for specific missions would not be required until 1966, but supporting activity, including advanced development, should be expanded above the present level of effort.

Third, continue long range planning of missions that might be initiated late in this decade or early in the 1970's. Appropriate research and development work to provide the science and technology for these missions should be carried forward. Such long range plans could include, for example, such manned areas as an Earth-orbiting space station, a lunar base with roving vehicle, and a planetary spacecraft.

This suggested pattern for future planning is reflected in the following detailed presentation of (1) present capabilities; (2) intermediate missions; and (3) long-range missions. It should be noted that the boundary between categories (2) and (3) is subject to constant re-evaluation and possible revision in the light of increased knowledge and changing events.

III. MAJOR CAPABILITIES EXISTING AND UNDER DEVELOPMENT

The broad categories of capabilities which have been developed during the past 6 years, or are to be developed in current programs, are shown in Figure 4. The major categories are Aeronautics, Satellite Applications, Unmanned Exploration, Manned Operations, Launch Vehicles, and Technology.

Aeronautics

The aeronautical program of NASA represents a continuation of a pattern of research activity developed by the National Advisory Committee for Aeronautics (NACA) over a period of more than 40 years. The in-house effort of this program is primarily basic and applied research activity at four NACA centers which were in existence in 1958 (the Langley Research Center, the Lewis Research Center, the Ames Research Center, and the Flight Research Center). This consists of in house and contracted-out work aimed at practical solutions of advanced problems of flight, but excludes the development of complete aircraft. Over many years the latter has been the responsibility of industry and other branches of the government with whom the NACA and now the NASA has developed effective working relations of collaboration and support.

For a number of years, the major portion of the NASA aeronautics effort has been in two areas. First, a basic research program in atmospheric flight. Three significant areas have received increasing attention -- major increases in maximum flight speed, major decreases in minimum flight speed, and major increases in operational flexibility. Second, a continuing research and technology program in support of military and other government agencies and industry has pointed to continued evolutionary improvement of existing aircraft types.

Figure 5 shows the aeronautical research effort of NASA classified by broad areas and gives an idea of the size and distribution of the effort for Fiscal Year 1965. In-house effort is carried on by about 500 research professionals supported by 1500 additional in-house personnel. In addition to the costs of these personnel, \$35.2 million of R&D funding for contracted-out research and development supports this effort.

MAJOR CAPABILITIES EXISTING OR UNDER DEVELOPMENT	
AERONAUTICS	MANNED OPERATIONS
R&D HYPERSONIC AIRPLANES	MAN IN EARTH ORBIT (1 TO 2 WEEKS)
OPERATIONAL SUPERSONIC MILITARY AIRPLANES	MANEUVER & RENDEZVOUS
COMMERCIAL SUPERSONIC AIRPLANES	LUNAR ORBITING, LANDING AND RETURN
IMPROVED SUBSONIC AIRCRAFT INCLUDING V/STOL	
SATELLITE APPLICATIONS	LAUNCH VEHICLES
SATELLITE PICTURES OF EARTH WEATHER	UP TO 125 TONS IN EARTH ORBIT
INTERCONTINENTAL COMMUNICATIONS (INCLUDING TV)	UP TO 47.5 TONS TO ESCAPE
UNMANNED EXPLORATION	TECHNOLOGY
NEAR-EARTH EXPLORATION	POWER SUPPLIES OF INCREASED POWER AND LIFE-TIME AND DECREASED WEIGHT
SOLAR EFFECTS	MORE ACCURATE GUIDANCE AND CONTROL
PLANETARY AND INTERPLANETARY PROBES	INCREASED COMMUNICATIONS CAPABILITY
LUNAR PROBES AND LANDERS	MORE ACCURATE STABILIZATION
BIO-SATELLITES	LIFE SUPPORT FOR LONG PERIODS
	IMPROVED LANDING CONTROL SYSTEMS
	INCREASED RELIABILITY

Fig. 4

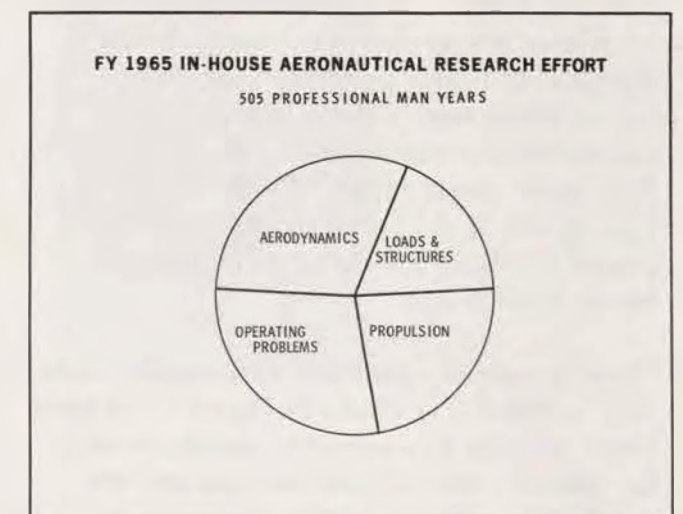


Fig. 5

Each of the four areas, Aerodynamics, Loads and Structures, Propulsion, and Operating Problems, is concerned with one of the major building blocks of aeronautics.

Aerodynamics, as the term is used here, is the study of the airflow around aeronautical vehicles and the resultant effects on the vehicles themselves. These effects lead to lift, drag, stability, controllability, and -- at higher speeds -- aerodynamic heating. The airflow also is responsible for the loads imposed on a vehicle. These loads must be predicted accurately for each vehicle and the vehicle structure designed to withstand them. To be efficient, each aircraft must use materials in a manner which will result in the lightest structure for a given design mission. Having determined the basic configuration, it is necessary to choose the appropriate type of propulsion system -- propeller, turbojet, ramjet, or rocket -- then to blend the structure and propulsion system into the best overall vehicle. This blending always requires compromises, and the strength of NASA's advanced research and technology programs is the Nation's foundation and main reliance for sound judgments.

The operating problems of aircraft, such as noise, sonic boom, flight safety, and aircraft flying and handling qualities, make up the fourth area of NASA's aeronautics work. In general, work in this area covers the many aspects of the aeronautical program not solely related to the other three academic-discipline areas.

Some illustrations of aircraft concepts that have drawn heavily on past NASA research, and are currently receiving heavy support to work out detailed problems of technology encountered in their development, are shown in Figure 6.

The novel aircraft are three V/STOL (Vertical-and Short-Take-Off-and-Landing) types. The upper tilt-wing type illustrates the tri-service, Vought-Hiller-Ryan C-142 that is currently undergoing initial flight tests. The tilt-duct type is another tri-service machine, the Bell X-22A now under construction. The fan-in-wing type shown at the bottom is the Army supported GE-Ryan XV-5A and is currently being flight tested.

Development of supersonic military airplanes such as the F-111 shown in Figure 7 has been made possible by years of cooperative work by industry, the military services and the NACA and NASA. NASA is now working with other government agencies and with industry toward the development of a supersonic commercial air transport (SCAT).



Fig.6



Fig. 7

Figure 8 shows one model of the supersonic transport being tested in the 40-by 80-foot wind tunnel at the Ames Research Center.

Satellite Applications

Significant successes have been achieved in NASA's applications satellite program during the past 6 years and the results are now being used to establish operational systems.

In the area of meteorology, nine TIROS satellites, launched since 1960, and one Nimbus satellite, launched in August 1964, have demonstrated the feasibility and value of Earth weather research and observation from satellites in orbit. One of the primary uses of the pictures returned by the TIROS satellite has been the identification and tracking of weather storms, including some 70 hurricanes and typhoons.

Based on NASA research and development success with TIROS, the United States Weather Bureau has adopted a modified TIROS system for its operational satellite system. This is expected to be ready during the winter of 1965-1966.

In the meantime, while we work toward operational systems, data from NASA's experimental TIROS weather satellites are used routinely by the Weather Bureau in the preparation of daily forecasts as well as for analysis in the area of climatology. The DOD also uses these data in the preparation of local forecasts in remote areas.

The Nimbus research and development weather (meteorological) satellite shown in Figure 9 is a significant advance over TIROS. Through three-axis stabilization and Earth orientation, continuous data on the Earth's weather is provided throughout its orbit. Its solar cells provide over 400 watts of power (10 times that of TIROS), and it can carry numerous types of meteorological experiments now emerging from our research program.

In addition to its television transmission system, the first Nimbus carried an Automatic Picture Transmission (APT) system and a High Resolution Infra-Red (HRIR) system. The APT system permits read-out of local cloud cover pictures by inexpensive ground stations, as shown by Figure 10, and will provide weather information to Department of Defense installations and the numerous foreign countries that have purchased or built, or plan to build, ground stations.

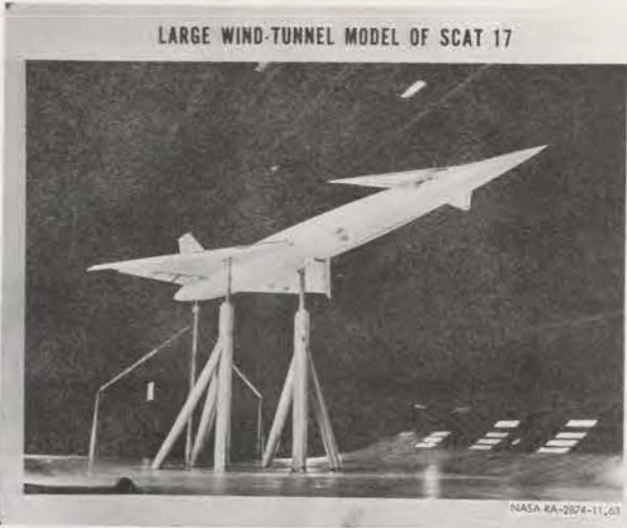


Fig. 8

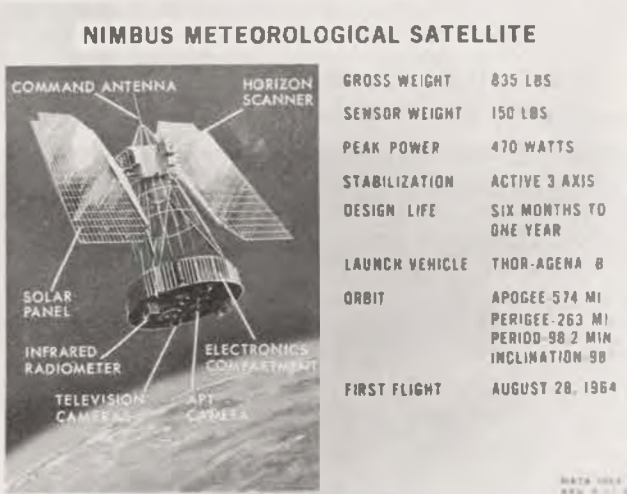


Fig. 9

A most significant achievement of Nimbus I was demonstration of the capability and value of the HRIR system, illustrated in Figure 11. This system enables us to obtain for the first time, in pictorial format and on a real time basis, cloud cover information from the dark side of the Earth. Cloud cover pictures such as these are reconstructed from measurements taken at night, and give an indication of cloud height as well as area coverage.

As illustrated in Figure 12, in the field of communications, the Echo passive satellite, and the Telstar, Relay and Syncom active satellites have experimentally proved out the technology for reliable, long-range point-to-point transmission of radio, television, telephone, teletype and facsimile via satellite. As a result, the Communications Satellite Corporation is now undertaking an international communications satellite system whose initial "Early Bird" satellite is based on NASA's Syncom.

Recently Syncom III, shown in Figure 13, transmitted real-time television of the Olympic Games from Japan to the United States. The precision achieved in the Syncom launch and positioning operations is indicated by the fact that Syncom III's period is almost synchronous and the inclination of the orbit is less than one-tenth of a degree from equatorial. This means that it moves north and south with respect to the Earth's equator less than 6 miles a day.

In addition to its primary communications function, Syncom has proved useful for scientific measurements used in better defining the shape of the Earth at the equator.

Unmanned Exploration

The basic objective of this NASA program is to acquire fundamental knowledge of the space environment and of those phenomena which can be studied best from spacecraft, for both scientific and practical purposes.

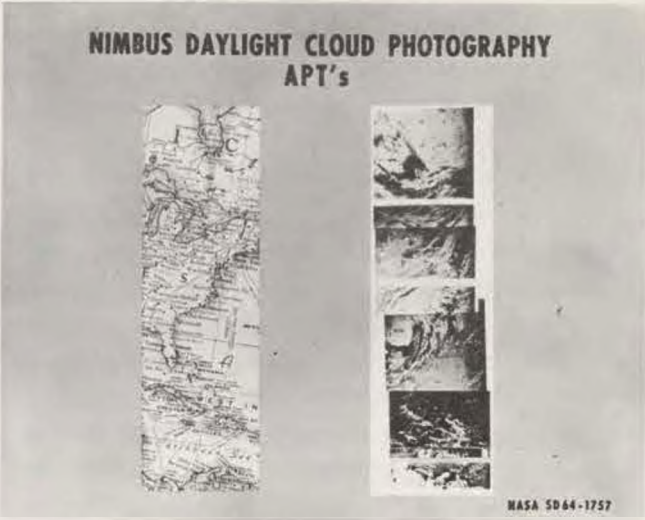


Fig. 10

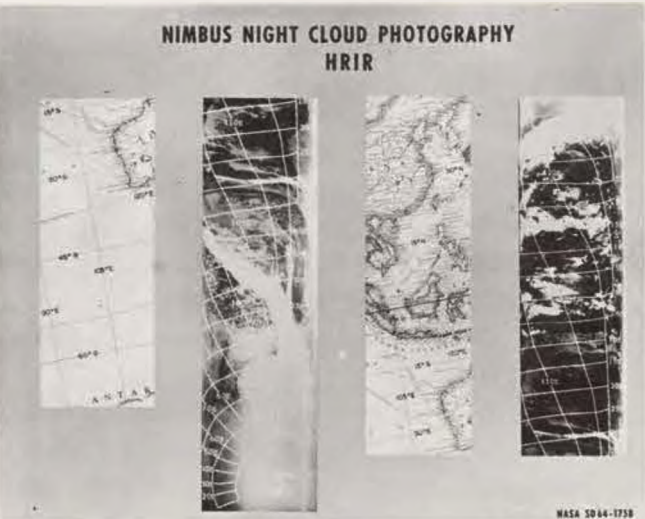


Fig. 11



Fig. 12

Major areas of interest are summarized in Figure 14.

The unmanned space exploration program was initiated in 1958 when instruments carried by the first of the Explorer series of satellites revealed the existence of the Van Allen Belts encircling the Earth. Since that date, 26 Explorer and Monitor satellites of the type shown in Figure 15 have been launched. These relatively small satellites, which have been placed in orbit by Jupiter C, Scout and Delta launch vehicles, are usually designed to make measurements of specific phenomena in space such as the distribution and energies of the particles trapped in the Earth's magnetic field (as with Explorers XIV and XV), ionospheric measurements to determine electron densities and their variation both diurnally and with changes in solar activity (as were made by Explorer VIII and the United Kingdom's Ariel I), or other phenomena such as micrometeoroid flux and atmospheric structure.

As an example of some of the findings of one of the newer Explorers (Explorer XVIII, launched November 27, 1963), Figure 16 shows the regions probed during the first 40 orbits of this Interplanetary Explorer (IMP-A). A transition region was found between the steady solar wind of interplanetary space and the magnetosphere, where the solar wind was turbulent and the magnetic field unsteady. Of extreme interest, also, was the discovery, on the fifth orbit, that the Moon as it moves through the solar wind apparently generates a wake that extends for a distance of at least 120,000 miles on the side away from the Sun.

This program of launching relatively inexpensive Explorer class satellites to make measurements of specific phenomena will be continued. A new series of Explorer satellites will carry payloads developed by universities and will also be used to continue international cooperation projects such as the U.K. Ariel I and II, the Canadian Alouette, and the Italian San Marco.

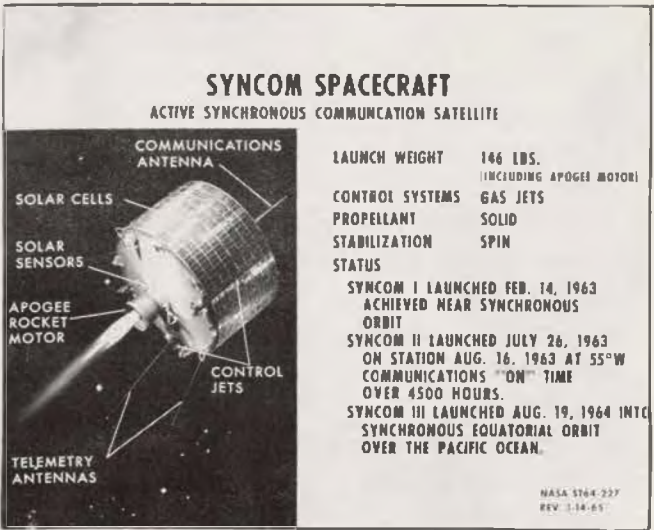


Fig. 13

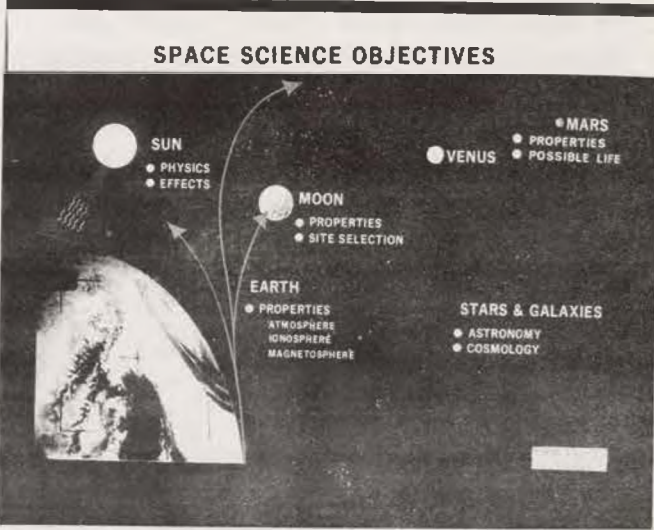


Fig. 14

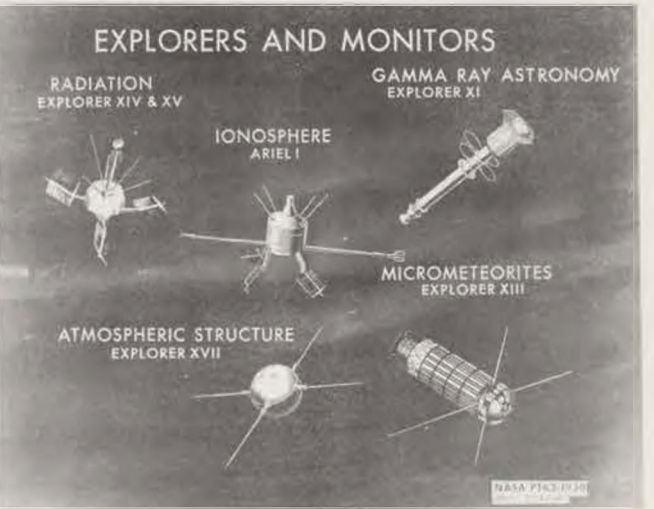


Fig. 15

The sounding rocket program is an important element of near-Earth exploration. It opens to investigation that vast region of the Earth's atmosphere that is too high for balloons to reach and too low for satellites. It also provides in-flight development testing of instruments and other equipment intended for later use in satellites. Further, new experimenters from universities, industry and foreign organizations are provided a logical and inexpensive way of gaining experience in space science techniques.

Shown in Figure 17 is the second generation of scientific satellites, the orbiting observatories. These larger satellites are designed to make more precise, more complex and better coordinated measurements of stellar, solar and geophysical phenomena.

The first Orbiting Solar Observatory (OSO), was launched in March 1962, and successfully reported data on solar phenomena for well over a year. The second OSO, launched in February 1965, will continue making solar measurements during the present quiet period of the solar cycle.

The first of the Orbiting Geophysical Observatories (OGO) was launched in September 1964 into a highly elliptical orbit. Although 2 of the long booms shown did not deploy properly and the satellite was not stabilized as intended, 18 of the 20 experiments are operating and many of the objectives will be accomplished. The OGOs are designed to carry 20 to 50 experiments and will allow correlated measurements of Earth-related phenomena at a single point in space.

The first Orbiting Astronomical Observatory (OAO) will be launched in late 1965 or early 1966 and will allow the first extended observations of stars and planets from above the Earth's atmosphere. An eventual goal in this series of satellites is to produce the capability of pointing a 36-inch telescope at a star to within plus or minus one-tenth of a second of arc, and one of its early experiments will be the mapping of the heavens in ultraviolet wave lengths.

Capabilities for interplanetary and planetary exploration were first successfully demonstrated by Pioneer V, launched in 1960, and by the Venus probe, Mariner II, shown in Figure 18, which was launched in August 1962. Pioneer V set a record for that time by communicating to Earth from a distance of 22,000,000 miles, and returned new data on the interplanetary environment. Mariner II, 109 days after it was launched, passed close to the surface of Venus

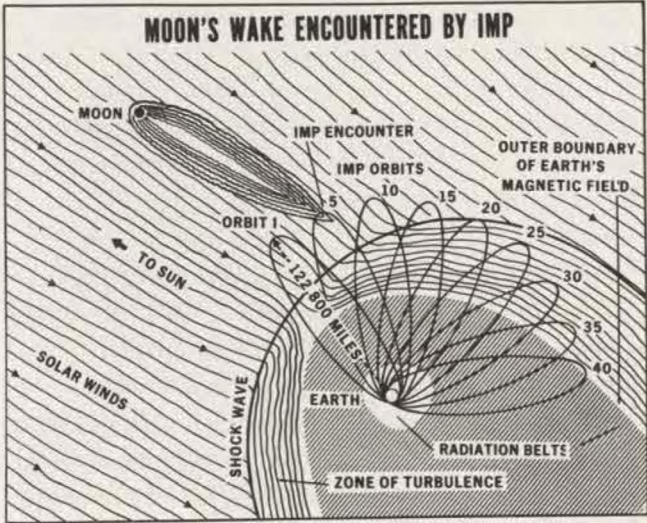


Fig. 16

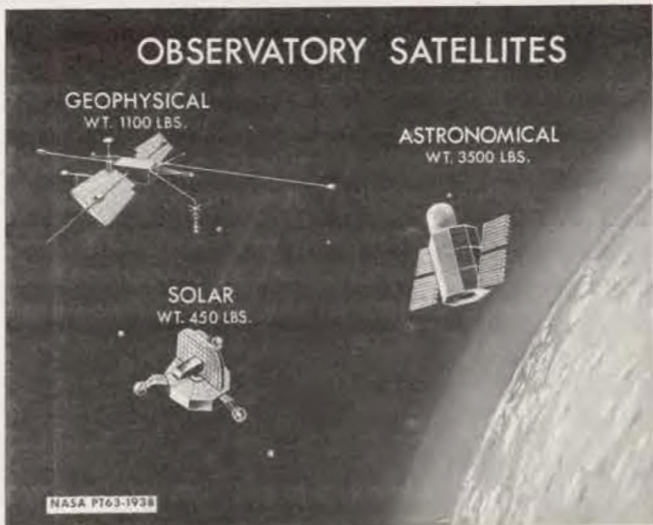


Fig. 17

and transmitted to Earth man's first close-up information about another planet. Although the data transmission capacity was limited, Mariner II gave us information on the surface temperature, magnetic fields, dust environment and radiation belts of Venus.

Mariner II also demonstrated the value of the mid-course maneuver capability on which we have standardized for guiding a spacecraft to a desired destination - in this case to within approximately 20,000 miles of Venus when it was 35,000,000 miles from the Earth.

The Mars probe, Mariner IV, was launched during the November 1964 opportunity. During its 8-month trip to the planet, this 575-pound spacecraft is making interplanetary measurements of the magnetic fields and solar winds. On arriving at the vicinity of the planet, the spacecraft, if operating properly, will make measurements of the Martian magnetic fields and radiation belts, collect some data on the Martian atmosphere, and will transmit to Earth about 20 television pictures of the planet's surface.

The Moon probe, Ranger VII, illustrated in Figure 19, gave man his first close-up look at the surface of Earth's nearest neighbor in space by transmitting approximately 4,300 television pictures to Earth in the last 15 minutes before it impacted on the lunar surface. Ranger also demonstrated our increased competence in mid-course maneuver capability, in this case to carry television cameras to within 10 miles of a preselected spot on the Moon's surface. It also demonstrated a communications capability for transmitting wide-band information over the quarter-million-mile Earth-Moon distance.

As illustrated in Figure 20, NASA is also developing the Lunar Orbiter and the Surveyor spacecraft for unmanned exploration of the Moon. Initial Lunar Orbiters, scheduled for launch in 1966, are designed to obtain topographic information by photographing an area of about 15,000 square miles with a resolution of 25 feet and of about 3,000 square miles with a resolution of 3 feet. Furthermore, the mass distribution and shape of the Moon can be determined from perturbations in the spacecraft's orbit. Later Lunar Orbiters will carry scientific instruments, as well, that will increase our knowledge of the lunar environment and of the surface and sub-surface characteristics. The Surveyor spacecraft is designed to land on the Moon and make measurements of the bearing strength and composition of the lunar surface, to take close-up, continuous panoramic TV pictures of the lunar surface, to measure seismic activity, and to determine the flux of primary

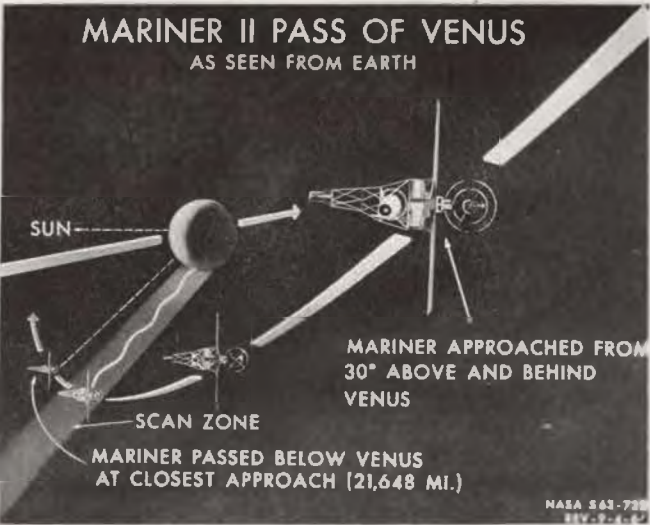


Fig. 18

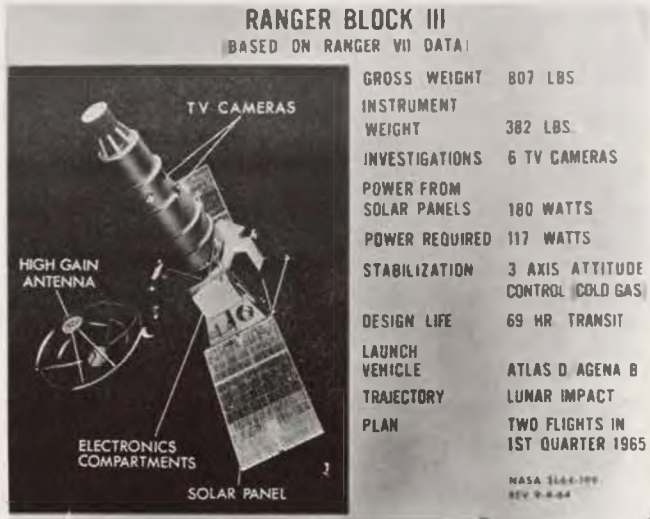


Fig. 19

and secondary particles impinging on the surface. The Surveyor and Lunar Orbiter will serve as a team to survey and select suitable sites for manned landings.

The biosatellite program consists of orbital flights up to 30 days of recoverable capsules, which contain various biological experiments, illustrated conceptually in Figure 21. The experiments carried will range from studies of the effects of weightlessness and radiation on elemental cell functions to investigations of heart and nerve functions in primates immobilized for prolonged periods in a weightless condition. This program will use thrust-augmented Delta launch vehicles and take advantage of the recovery techniques developed by the Air Force in the Discoverer program.

Manned Operations

As illustrated in Figure 22, the current manned operations program provides an orderly progression of operational capabilities from the 2,900-pound Mercury spacecraft to the 7,000-pound Gemini, to the 95,000-pound Apollo-LEM system.

Figure 23 illustrates the progression of manned launch vehicles from the 368,000 pound thrust Atlas which launched the Mercury spacecraft to the 7 1/2 million-pound thrust Saturn V which will launch the Apollo.

The Mercury spacecraft, launched by the Atlas, provided this country's first capability for manned Earth-orbital flight and was used in the 3-orbit mission by John Glenn in 1962. The Mercury-Atlas system capability was later extended to accomplish Gordon Cooper's 22-orbit, 34-hour flight in 1963.

The Gemini two-man spacecraft, with its Titan II launch vehicle, will make possible missions of up to 14 days in Earth orbit, beginning in 1965. New equipment will permit orbit change, rendezvous and docking, and will enable the astronauts to venture out-

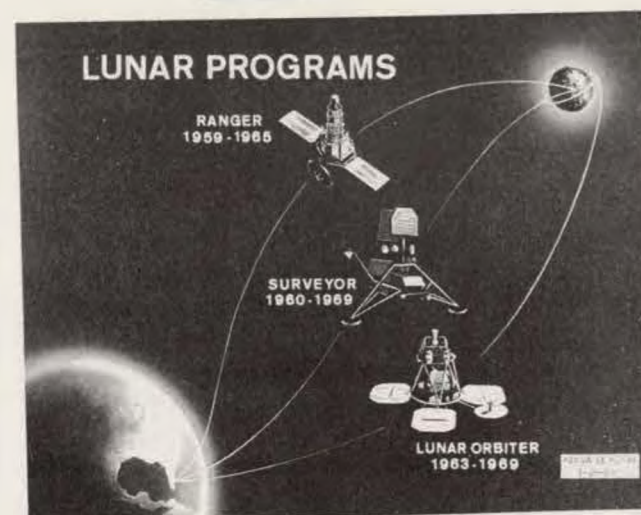


Fig. 20



Fig. 21

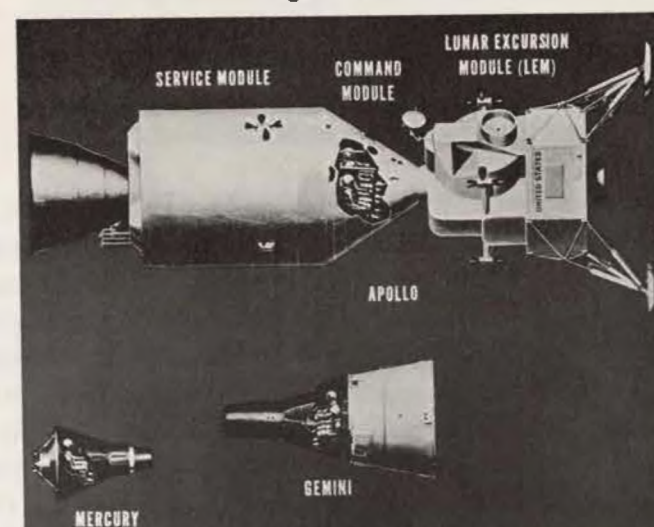


Fig. 22

side the spacecraft into free space. Dual launches of the Gemini by Titan and the Agena by Atlas will place an unmanned Agena target into orbit and enable the Gemini astronauts to perfect the rendezvous and docking systems. These missions will verify the operations and techniques to be used later in the more ambitious Apollo missions.

In Project Gemini, NASA is providing a flexible, experimental space tool with which to flight test equipment, conduct scientific experiments, and develop techniques and provide training for Project Apollo. The Department of Defense Manned Orbital Laboratory will also make use of Gemini for the launch and return to Earth of the astronauts who will work in the laboratory.

As illustrated in Figure 24, the Gemini spacecraft consists of two major elements, the reentry module and the adapter, with a combined weight of 7,000 pounds. The reentry module provides life support and control equipment for the two crewmen, contains most of the experiments and also contains the rendezvous and recovery systems. The adapter element provides the link between the Titan II launch vehicle and the reentry module, and is composed of two sections, an equipment section to provide augmented life support, stabilization equipment and expendables for flight durations of up to 14 days, and a retrograde section to slow down the spacecraft from its orbital velocity.

Several of the Gemini missions are designated primarily as rendezvous missions to explore the feasibility of various modes of accomplishing rendezvous utilizing different levels of automation in the sensing and control equipment.

In a typical mission, an Agena engine will first be launched into a 160-nautical-mile circular orbit. The manned Gemini spacecraft will then be placed into a lower circular orbit at 130 nautical miles. The different periods of the two spacecraft in these concentric orbits will cause a continuing change in the relative position of the Gemini with respect to the Agena. When the relative positions are proper, the Gemini spacecraft will be accelerated in a transfer ellipse to the higher orbit where the rendezvous and docking will be accomplished. These missions will be short-lived because of the weight requirement for fuel which reduces the expendables that can be carried for life support, power supply, and stabilization.

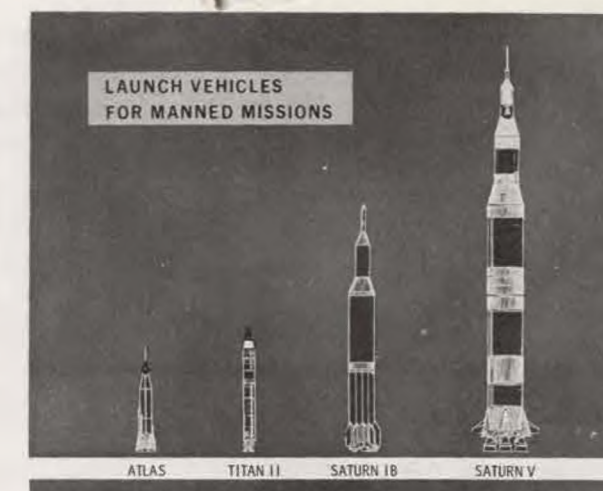


Fig. 23

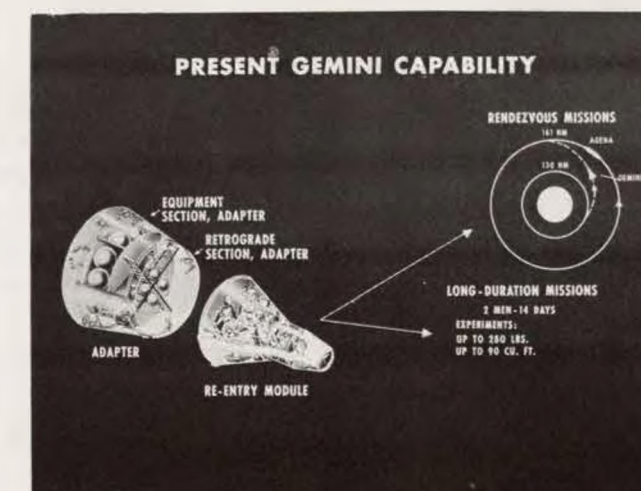


Fig. 24

On the Gemini long-duration missions, primary emphasis will be placed on biomedical and behavioral aspects of man in a weightless condition; however, scientific and technical experiments are being planned for all missions. Specific experiments range all the way from visual definition experiments requiring no equipment and astronomical observations made with a 2-pound ultra-violet camera to radiometric or astronaut maneuvering experiments using equipment weighing as much as 200 pounds. The experiment program is tailored to the available weight, volume, and power in the spacecraft on each mission, as well as to the participation and accessibility which can be provided for the astronauts. Although the volume available for experiments within the pressurized cabin is limited, extra-vehicular operations are planned for the astronauts to permit free-space experiments, maneuvering, and other external operations such as the testing of manual dexterity and the use of specialized tools for spacecraft repair functions.

The Gemini spacecraft is already undergoing flight test. The successful launch of the first and second unmanned Gemini's in April 1964 and January 1965 will be followed soon by the first manned orbital flight. The easy access to the crew compartment is emphasized in Figure 25, which shows the Gemini spacecraft mockup.



Fig. 25

The larger goals of the presently planned manned space flight program will be attained by the three-man Apollo-LEM system to be launched by the Saturn IB beginning in 1966 and by the Saturn V beginning in 1967. The Apollo Command and Service Modules, with fuel partially removed, will be launched first by the Saturn IB for Earth-orbital missions of up to 10 days duration. A number of such flights will be made in which rendezvous, docking, maneuvering, and other operations will be conducted.

Later, the total 47.5-ton Apollo-LEM spacecraft will be qualified in Earth orbit and eventually propelled to the Moon by the Saturn V, thus extending the area of space in which man can operate from near-Earth orbit to as far out as the Moon, and including the lunar surface.

The size of the Apollo-LEM spacecraft, shown previously in Figure 22, as compared with either the Mercury or Gemini spacecraft, is in part due to the longer duration of the Apollo missions, the larger heat-shield, and the increased crew; however, the major increase is due to the requirements for a large propulsion capability for maneuvering in space. The Service Module provides a propulsion capability for mid-course correction, lunar-orbit braking, and lunar-orbit escape, while the Lunar Excursion Module provides the capability for lunar landing and lunar takeoff.

The very large capability of the Apollo space exploration system (illustrated in Figure 26) will open a new era in manned space flight. Earth-orbital missions reaching out to synchronous orbit distances and of 14 days duration can be conducted, and lunar and other missions out to lunar distances will be possible, including one-day stays on the lunar surface for two men, or

4 days stay in lunar orbit for three men.

On Earth-orbital, lunar-orbital, and lunar surface missions, provision is being made for the conduct of an extensive experimental program. Because of the increased size and the presence of man, these experiments will, in general, be more complex and extensive than those performed in unmanned vehicles. In the Command Module, volume has been provided for about 3 cubic feet of experimental equipment and with a return-to-Earth capability of about 80 pounds of instruments or lunar samples. In the Service Module, a complete empty bay provides an available volume of 250 cubic feet for the mounting of instruments; the weight available would depend upon the particular mission and the amount of fuel or other expendables required.

In the Lunar Excursion Module, 2 cubic feet of experimental equipment, weighing up to 80 pounds, can be installed within the existing ascent stage, and 15 cubic feet of instruments, weighing up to 250 pounds, on the descent stage in an area accessible to the astronauts while standing on the lunar surface. On all missions, however, the permissible weight of experiments must be evaluated against the comparable weight of expendables for fuel and life support, in order to extend the maneuver capability or duration of the mission.

A better impression of the room provided for experiments, as well as the progress that is being made in finalizing the design concept of the Apollo-LEM system, can be gained from the mock-ups of the major spacecraft elements shown in Figure 27. The area in the exposed bay in the Service Module could be utilized for installation of instruments that do not need direct monitoring by the astronauts. This space might also be used for carrying complete unmanned spacecraft in a piggy-back fashion for later deployment on unmanned space missions or for lunar surface probes.

Launch Vehicles

Figure 28 shows the boosters now included in the National Launch Vehicle Program which range from the Scout vehicle, capable of placing about 325 pounds in a 100-mile Earth orbit, to the Saturn V which will place about 250,000 pounds in the same orbit. The Thor/Delta vehicle, which will place about 930 pounds in a 100-nautical-mile Earth orbit or propel a 105-pound payload to escape velocity, has been the most successful of U. S. launch

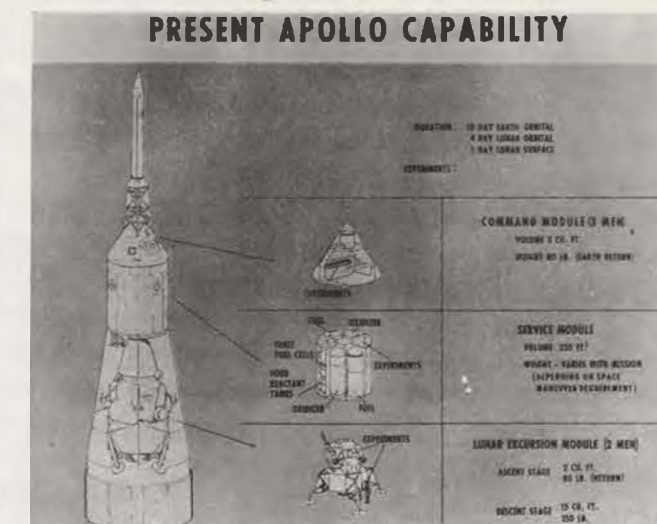


Fig. 26



Fig. 27

vehicles, placing 26 payloads in Earth orbit out of 29 attempts. The capacity of the Thor/Delta has been improved recently by the addition of three 33-inch diameter strap-on solid rocket motors, giving about 25 per cent increase in Earth orbital payload capability. The thrust-augmented Thor/Agena will be capable of placing about 1,800 pounds in Earth orbit, when launched from the Western Test Range.

The two Atlas-based vehicles are the Atlas Agena and the Atlas/Centaur. The Atlas Agena can place up to 6,300 pounds in Earth orbit. It has been used successfully to launch the 750-to 800-pound Ranger probes to the Moon; and, on November 28, launched the 575-pound Mariner IV to Mars. The Atlas/Centaur, nearing completion of development, will accelerate 2,300 pounds to escape velocity or 9,700 pounds to Earth orbital velocity. It will be used as the launch vehicle for the Surveyor spacecraft designed to achieve a soft landing on the Moon.

The Centaur was the first rocket stage to use hydrogen and oxygen as fuel, a combination which gives an increase in specific impulse from about 300 seconds, available with standard fuels, to more than 400 seconds. This is an improvement of particular importance to missions requiring velocities equal to, or higher than, that for Earth escape.

The Titan series of launch vehicles is under development by the Department of Defense. The Titan II is used by NASA to launch the 7,000-pound, 10-foot diameter Gemini spacecraft. The Titan IIIA (not illustrated) consists of the Titan II to which an additional stage, called the trans-stage, has been added. The addition of two 120-inch solids to the IIIA produces the IIIC (illustrated in Figure 28), which will place about 25,000 pounds in low Earth orbit or propel about 5,000 pounds to escape velocities.

In the Saturn family of vehicles, the Saturn IB is capable of placing 35,000 pounds in Earth orbit; and the Saturn V, 250,000 pounds. The Saturn V will also accelerate 95,000 pounds to Earth escape velocity.

The Saturn program indicates the use of standardized rocket engines. The first stage of the Saturn IB is made up of eight LOX-RP-1 fueled H-1 engines -- an up-rated version of the S-3 engines that were developed for the Atlas booster. The upper stage of the Saturn IB uses one hydrogen-oxygen J-2 engine which will also be used in a cluster of five to power the second stage of the Saturn V.

In the Saturn V, five 1,500,000-pound thrust F-1 engines power the first stage. The second stage will use five J-2 engines. The third stage uses one J-2 engine and is almost identical to the second stage of the Saturn IB.

These vehicles thus provide a wide range of launch capabilities based on a minimum number of

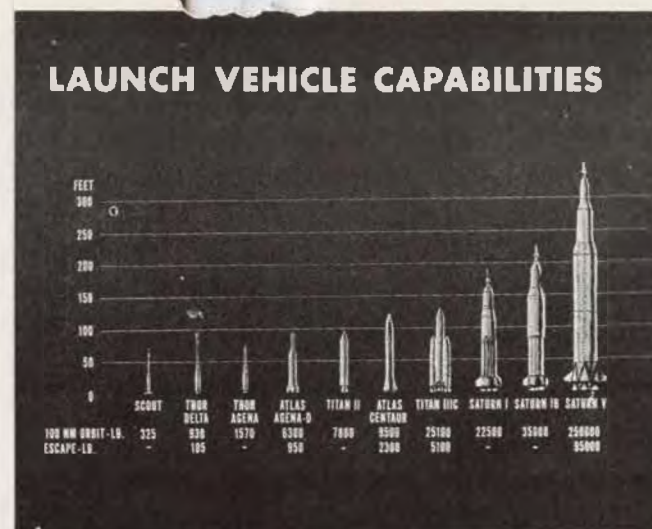


Fig. 28

engine types. However, it is important to note that there are wide gaps in escape payload capability between the 950 pounds of the Atlas/Agena, the 2,300 pounds of the Atlas/Centaur, the 5,100 pounds of the Titan IIIC, the 13,000 pounds of the Saturn IB/Centaur, and the 95,000 pounds of the Saturn V.

Technology

The technological base which supports the development of the mission capabilities described has been made possible by the experience gained by our military services in the ballistic missile program and the broad research and technology development programs carried on by industry and by NASA. When the space age began in 1957, the reserve of technology which could be tapped to meet the immediate needs of the United States proved insufficient. The reliability and thrust of the launch vehicles, for example, were far short of that required to meet the challenge of the Soviet space program. However, due to the foresight exercised at that time in undertaking, without specific end uses in sight, the development of the 1-1/2 million-pound thrust F-1 engine, and other important projects, this country was able to make sound technical decisions when it became necessary to expand its space program in 1961. This expanded program is designed to assure United States leadership in space and to be ready to respond when national needs or objectives require new aeronautical or space systems. With respect to such a large, complex, and unknown environment as space, and the still not precisely defined characteristics of the Earth's atmosphere, this Nation would be oblivious to the lessons of history if it required that all its exploratory research and development efforts be matched to completely defined missions. It is clear from the 1958 Aeronautics and Space Act that NASA was established to make sure we would develop the capability which was clearly lacking at that time, and to develop the kind of policies and priorities that would do the job needed. Where there is reasonable promise of success in the development of such things as new materials, propulsion systems, or techniques, it is NASA policy to pursue these directions even though a specific use is not clearly defined. We have found that we can organize these efforts so as to point at broad classes of possible uses, giving the necessary technical base for options as to missions and the best ways to accomplish them. In his testimony before the Committee on Science and Astronautics on February 4, 1964, Dr. Hugh Dryden recalled how the United States, despite initial positions of advantage, failed to carry forward work of which it was capable in aeronautics, in jet propulsion, in ballistic missiles, and in the launch vehicles and spacecraft necessary for space exploration. The result in each case was that other nations moved ahead, placing the United States at a disadvantage and requiring an enormous effort to catch up. Our present relative position in space leaves no room for complacency. As Dr. Dryden said, "We must not delude ourselves or the nation with any thought that leadership in this fast moving age can be maintained with anything less than determined, whole-hearted, sustained effort."

It is on this basis that NASA is continuing to carry out a broad, long-range program in research and technology development. This program is aimed at the establishment of future mission capability, and it can be expected that new advances in technology will be made and will provide a better basis of judgment than we have had before as to the value of missions and projects and as to when they can be undertaken at reasonable costs and risks.

In the next two sections of this report, dealing with intermediate and long-range missions, we shall attempt to identify, when possible, the technological advances that are required for their accomplishment. These research and technology development programs will be discussed in

detail following the section on long-range missions.

Some examples of the capabilities which have been, or are being, developed to date are:

- a. Solar cell power supplies capable of producing 650 watts.
- b. Guidance and control capabilities for placing a spacecraft within a few thousand miles of a distant planet, or within a few miles of a given point on the Moon.
- c. Communications technologies which provide almost continuous communications with manned spacecraft in Earth orbit, the transmission of about five television pictures per second from the Moon, or radio reception from a spacecraft over a 100 million miles in space.
- d. Spacecraft stabilization technology which will enable precision instruments to be pointed, in some instances, to within 1/10 second of arc.
- e. Life support systems which will enable three men to remain in space for as long as 14 days and to venture as far as 250,000 miles from the Earth.
- f. The reliability of both spacecraft and launch vehicles. Spacecraft reliability has been improved to the point where many unmanned spacecraft now have lifetimes of well over one year, and manned spacecraft will be capable of dependable operation for 14 days or longer. Reliability of launch vehicles has been improved to such an extent that the per cent of successful vehicle launches has risen from about 60 per cent in 1960-61 to over 90 per cent at the present time.
- g. A world-wide tracking, data acquisition, and communications system to support manned flight, scientific and application satellites, injection, monitoring, and deep space probes, as illustrated in Figure 29.

Along with the missions which are being undertaken and the capabilities which are being developed, the first years of the Nation's effort in space have produced a broad scientific and industrial base, and the facilities and management systems needed for carrying out an effective program of space exploration.

A major part of our present space capability is found in the expansion of NASA since 1961. About 2-1/3 billion dollars have been invested in strengthening the industrial facilities and government laboratories associated with aeronautical and space research and in adding new installations. These include the Goddard Space Flight Center in Maryland, the Michoud Plant at New Orleans, the Mississippi Test Facility in southern Mississippi, the Manned Spacecraft Center at Houston, Texas, and the New Merritt Island Launch Facility at Cape Kennedy, of which the Saturn/Apollo Vertical



Fig. 29

Assembly Building is shown in a cutaway view in Figure 30. The exacting demands of space systems in the electronics field have also required a new Electronics Research Center which will conduct and supervise research in this vital field from its location in Cambridge, Massachusetts.

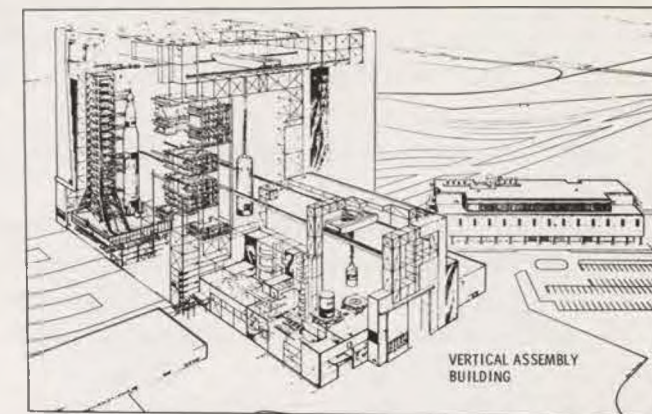


Fig. 30

NASA has contracted out more than 90 per cent of its research and development work. Over 1,600 manufacturing firms have held prime contracts of over \$25,000 and about 20,000 firms have worked under prime or sub-contracts. Surveys made by 12 major prime contractors disclosed 3,000 sub-contracts of over \$10,000 to sub-contractors located in all 50 states. During slightly over 6 years of operation, NASA contracts have totaled more than \$13 billion, adding great strength to the country's industrial base.

The conduct of space research and development, involving the design and manufacture of the most complex systems ever attempted, is demanding major improvements in methods of conducting large-scale organized effort. Included are new methods of production control, systems integration and checkout, and reliability and quality control.

The substantial expense involved in launching space vehicles, and the intricacy of the devices involved, have imposed unusual requirements of precision manufacture and quality assurance. As a consequence, increasing reliance is being placed upon incentive contracts, and new ways of encouraging improved government personnel and contractor performance are being developed.

The space program is indeed a large and varied research and development effort. The harsh environment of space requires major advances in all areas of technology, in materials, in electronics, in propulsion, in guidance and control, in power sources, in lubricants and coolants, in communications, in the integration of systems and the establishment of high levels of reliability, and in the maintenance of human life in space. It is already clear that our balanced and broadly-based space effort is producing important scientific and technological advances that are not limited to space use.

Experiments or pilot model efforts, through which these advances constituting major National resources for both security and economic growth can be made available quickly and efficiently for non-space use, are being carried out. NASA has established a program in technology utilization, with headquarters in Washington and with offices in each of the NASA centers. Innovations are being identified and described in appropriate publications; these are disseminated widely. Regional dissemination centers have been established on a trial basis at a number of universities. At each of these, NASA material is put on computer tapes and access provided to industrial concerns who support these centers through user fees and contributions. This system makes this material available within about 6 weeks of it's reporting date to Headquarters from both NASA centers and contractors, and makes it available on a selective basis conforming to the interests of the users. The system also provides a method by which the user can secure

complete, in-depth information on any advance in an area of particular interest. The objective of this program is to spread the advanced technical industrial capabilities developing in the space program within and beyond the government contractor population to the maximum extent practicable, and particularly to bring about the identification and practical utilization by American industry of new processes and products developing in the space program.

Scholars in the Nation's universities conduct much of the basic research, and prepare many of the experiments required for advances in space science. The breadth of the program has produced, at many universities, new requirements for interdisciplinary cooperation and participation among the scientific specialties, and between science and engineering.

NASA-supported research effort in universities involves both project-related research, as illustrated in Figure 31, and a Sustaining University Program comprised of training, research and facilities grants. Under the training program, 142 universities have received grants to support a total of 3,132 candidates for predoctoral training fellowships in space-related fields. Research grants under the Sustaining University Program have been made to 53 educational institutions, most of them involving interdisciplinary effort, and many of them "seed grants" aimed at strengthening research activity at universities capable of expanding their research programs. A total of 27 facilities grants (shown in Figure 32) have been made to universities to provide additional laboratory space required in the performance of space-related research.

A significant element in the overall NASA-university effort, particularly in the case of those universities receiving facility grants, is the encouragement of a closer working relationship between the university research activities and those businesses and industries with which the university already has close relations. This aims to facilitate the transfer of space research results to practical, industrial application. Memoranda of understanding accompanying the facility grants provide that the university will, in an organized and interdisciplinary manner, seek ways in which such transfers can be achieved, and strive for closer relationships with the business community.



Fig. 31

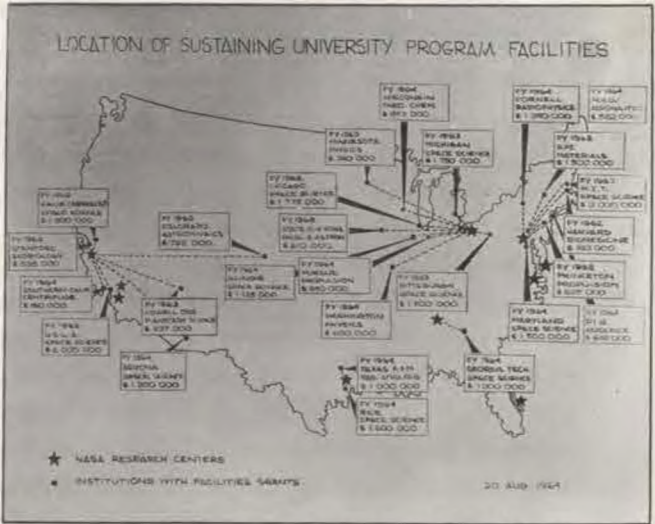


Fig. 32

Participation in the U. S. space program has not been limited to this country. Individuals or agencies in 69 nations throughout the world have joined the United States in space projects, including the establishment of tracking and data acquisition stations, as illustrated in Figure 33. In all of these projects, cooperation has been literal and substantive, requiring significant contributions from both sides, without financial exchange, and meeting the test of scientific value.

NASA has launched four satellites in cooperation with Great Britain, Canada, and Italy and has existing agreements to launch others with all of these countries as well as with France and the European Space Research Organization. The present practice in these projects is that the cooperating country conceives and engineers the complete satellite, using its own resources.

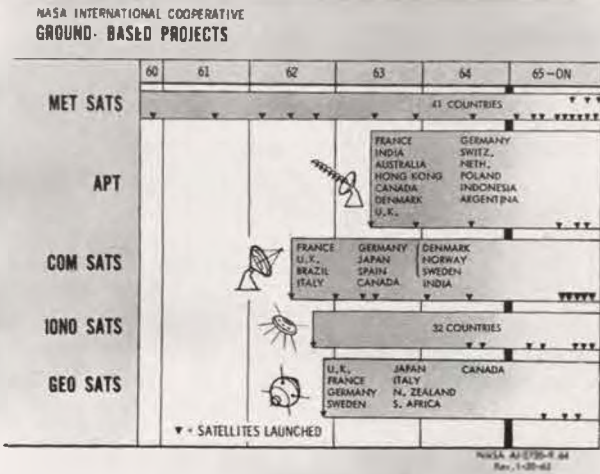


Fig. 33

Individual experiments proposed by foreign scientists, sponsored by their governments and selected on their merits, are also accommodated in NASA satellites. One British experiment flew on Explorer 1, and 12 other British, Dutch, and French experiments are scheduled for inclusion on NASA satellites which will be launched over the next few years.

NASA has participated in cooperative sounding rocket projects with 14 countries, involving more than 100 cooperative launchings, and currently has agreements for launching nearly 50 more in such projects. The multitude of foreign sites established for this program and the extent of capability stimulated by it vastly increase the possibilities for synoptic research, while reducing its cost.

A wide variety of ground-based cooperative projects involving foreign scientists has been organized to produce observations or measurements enhancing, and sometimes even necessary to, NASA's orbiting experiments. Thus, 42 countries have collected local meteorological information for correlation with TIROS observations, and 11 countries have already built, or will soon complete, ground terminals necessary for test transmissions in connection with our communications satellite programs.

Under international scientific and technical personnel exchanges, 103 gifted foreign Research Associates have contributed their talents to work in NASA centers, 84 International Graduate Fellows have trained in U. S. universities, and 180 foreign technicians have trained at NASA centers in support of cooperative projects and ground facility operations.

This completes the review of the capabilities which have been developed during the first 6 years of space exploration, or which will be developed within this decade.

IV. INTERMEDIATE MISSIONS

The intermediate missions to be discussed in this section and shown in Figure 34 meet three major tests:

- They support immediate needs for continued developments in space science and technology.
- They make efficient use of the boosters, spacecraft, and ground facilities developed and paid for within the current program.
- They provide for steady progress toward the ultimate accomplishment of longer range goals in space.

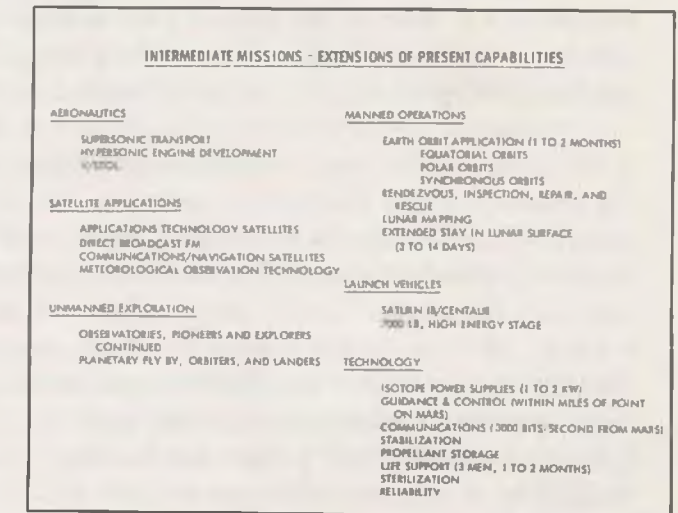


Fig. 34

As in the preceding section, the major subjects to be covered in the discussion of intermediate missions will be aeronautics, satellite application, unmanned exploration, manned operations, launch vehicles and technology.

Aeronautics

In the field of aeronautics, NASA is continuing its work in aerodynamics, structures, propulsion, and flight operations to insure the continued superiority of U.S. aircraft. NASA research capabilities will continue to be utilized to provide technical guidance to those agencies and industrial concerns engaged in the supersonic transport development. In the near future, an experimental flight program using the Air Force XB-70, to investigate more fully the characteristics of flight at Mach 3, will be jointly carried out with the Air Force.

In the realm of subsonic flight, NASA research will continue to encompass aircraft of conventional type, and V/STOL aircraft. Work now in progress indicates that the technology for subsonic jet transports of improved efficiency and safety will be forthcoming within the next few years. Research on STOL aircraft will be continued to encourage development of aircraft of this type. The continued improvement of the personal owner and light business type aircraft will be supported by research aimed at obtaining greater flexibility of operation, easier flying characteristics, and increased safety and utility.

Work will also continue in the field of VTOL aircraft for both military and civil uses. It is anticipated that flight research studies of these and other similar type aircraft, together with continued wind tunnel, simulator, and analytical studies, will provide additional design and operational data. These data will make possible development of practical military V/STOL aircraft capable of operating out of relatively unprepared areas, as well as larger vehicles which might satisfy commercial passenger transportation needs in highly developed areas. In addition, research on hypersonic propulsion and aerodynamics will be continued.

Several studies have been made which indicate a real potential for useful flight missions in the atmosphere at hypersonic speeds (Mach numbers 4 to 8) using air breathing ramjet engines - - if theoretical engine performance can be achieved in practice. Engines of this type may eventually be needed for long-range, high-speed commercial and military aircraft applications, and may find a useful application in recoverable boosters.

A difficult problem associated with development of a production engine of this type is that the ground facility needed for testing such a full-scale engine might be as difficult and as expensive to develop as the engine itself, and may even be beyond the present or foreseeable state-of-the-art. For this reason it has been proposed that the X-15 airplane be used as a flying test bed in conjunction with modest ground test facilities, for proving out a small, 18-inch ramjet engine at speeds approaching Mach 8, as illustrated in Figure 35. These tests, made in a real environment at the proper Mach numbers, altitudes and dynamic pressures, will help establish the feasibility of hypersonic ramjet engines and contribute to the technology needed for design of future full-scale engines and, ultimately, useful hypersonic aircraft.

Another part of the continuing aeronautics program includes the study, design and testing of aerodynamic shapes suitable both for reentry into the Earth's atmosphere at orbital velocities and for landing at subsonic speeds in a conventional manner. These aerodynamic shapes (referred to as lifting reentry bodies) will be applicable to many longer range future developments such as recoverable orbital transports, hypersonic aircraft and, possible, recoverable boosters.

Figure 36 shows an early configuration whose subsonic flight and landing characteristics are being tested at the NASA Flight Research Center.

Special emphasis will be placed on operational problems such as the noise level of supersonic aircraft (including sonic boom), air traffic control, and zero-visibility landing which can establish boundaries limiting the utilization of the aerodynamic, propulsion, and structures advances which aeronautical research can make possible. Close cooperation with the Federal Aviation Agency, the Civil Aeronautics Board, and the military services will be continued.



Fig. 35



Fig. 36

Satellite Applications

In the area of space applications, NASA's role is that of continuing the advancement of technology needed for the success of operational satellite systems or for support of other NASA missions. In accordance with basic agency policy, operation of meteorological, communication or navigational systems will not be undertaken.

Studies of prospective space application missions show that spacecraft in synchronous (either inclined or geostationary at 22,300 miles) and in 800-mile polar orbits will be particularly useful.

A synchronous meteorological satellite would permit a continuous view of a large area of the Earth, thus eliminating many of the difficulties inherent in taking data between the successive passes of lower altitude satellites. Meteorological satellites in polar orbits are useful where world-wide coverage is needed.

Communication and navigational satellites also take advantage of a fixed position relative to the Earth provided by geostationary orbits. Many problems due to the continuously changing position of lower orbits are eliminated. The complexity, number and cost of antennas may be reduced significantly. Similarly, stationary orbits will be highly desirable for future direct FM or TV broadcast satellites.

To place a satellite in a polar orbit requires more energy than to place it in a low inclination orbit. Even more energy is required to place a satellite at 22,300 miles in a synchronous orbit, and still more in a geostationary orbit. There is, therefore, a need for a small high energy stage on the Atlas/Centaur to provide additional energy for converting inclined transfer orbits to true stationary (synchronous equatorial) orbits. For 10,000-pound applications satellites of the future, Saturn IB/Centaur vehicles will be needed.

The Applications Technology Satellite, illustrated in Figure 37, will be used to develop further the technology of meteorological, communications, and navigation satellites in synchronous orbits. Among these technologies are long-life active and passive stabilization systems, possibly using gravity gradient methods; techniques for accurately erecting and pointing large aperture antennas in space; and the flight test of infra-red and TV sensors for use in meteorological satellites at synchronous altitudes. These satellites will be further used to test advanced components and subsystems applicable to many other satellite systems. These spacecraft can be launched by Atlas/Centaur vehicles.

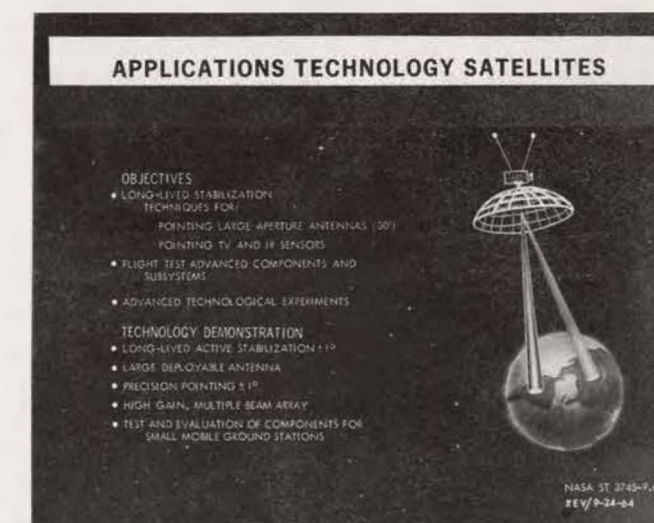


Fig. 37

Direct broadcast FM satellites, illustrated in Figure 38, can be placed in synchronous orbit to develop and demonstrate the techniques of broadcasting directly to home receivers from satellites in space. Direct broadcast satellites would be useful for bringing radio to remote areas where ground broadcast stations are not available, and would also have other potential usefulness for furthering cooperation with other nations.

As presently conceived, such a satellite would be placed in orbit by an Atlas Centaur, with a 7,000-pound high energy stage, or possibly by a Saturn IB/Centaur. It would transmit about one kilowatt of FM power. It will require the development of a stabilization system accurate to plus or minus 1 or 2 degrees and a 3-kilowatt power supply, which could be achieved by the use of radioisotopes.

Also under serious consideration is the development of a combination communication-navigation satellite as illustrated in Figure 39. This satellite would be capable of determining the location of ships and airplanes with high accuracy and furnishing this information to both the vehicles and to ground control stations. It is anticipated that the development of supersonic transport airplanes will magnify the problems of aircraft traffic control. Communication-navigation satellites could be instrumental in systems to meet this problem. The more accurate positioning of ships at sea that could be realized from such a satellite would result in savings in operating costs, and, in the event of a disaster, could materially enhance the rescue operations.

In the Nimbus meteorological satellite series, NASA will continue to develop meteorological satellite technology, concentrating in the areas of improved infra-red and TV sensors, spectrometers, and interferometers. Also to be tested in further Nimbus flights are various components and techniques that may be used in future automated space data-collecting systems. Such systems would collect meteorological and other information from sensing devices such as buoys at sea, meteorological ground stations, or perhaps constant-altitude weather balloons.



Fig. 38



Fig. 39

The developments in the Nimbus program will contribute to our capability to identify and track weather fronts and storms from hour to hour and from day to day. Also, it will provide some of the quantitative data for use in electronic computing machines for predicting the weather over longer periods of time. Finally, as a meteorological observatory, Nimbus will provide special observation to improve our understanding of the composition of our atmosphere, its vertical components, and its behavior.

Unmanned Exploration

In the area of unmanned space exploration, many current programs will be continued and, in some cases, extended. In the Pioneer program, spacecraft such as that shown in Figure 40 would be launched both toward and away from the Sun. These spacecraft, weighing approximately 140 pounds, will be placed on a trajectory such that approximately 6 months after launch they will be 50 million miles from the Earth, and, depending upon the direction launched, either 0.8 or 1.2 astronomical units (AU) from the Sun. The spacecraft will carry instrumentation to investigate such things as magnetic fields and the temperature and velocity of the solar wind in the interplanetary medium. Also of interest would be the distribution in space of the solar protons emitted from solar flares and the micrometeoroid distribution in the region of the Earth's orbit about the Sun.

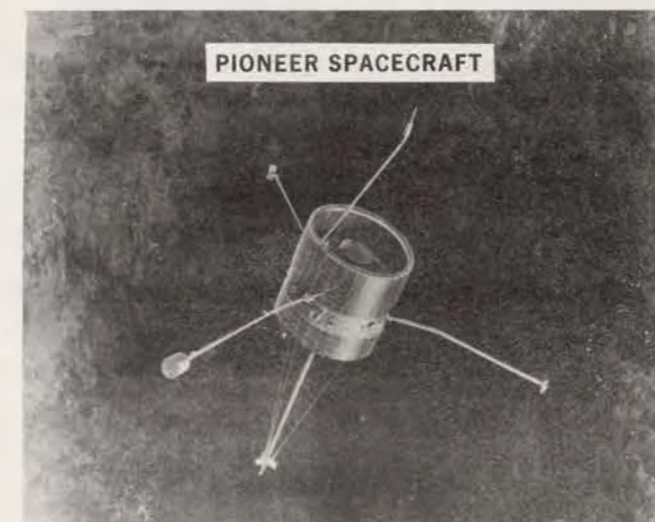


Fig. 40

Initially, the Pioneer spacecraft will be launched by an improved thrust-augmented Thor-Delta booster and will, to a great extent, draw upon existing technology and communication facilities. Present plans also call for Pioneers to be flown during the period of maximum solar activity in 1968-72. During this period, the spacecraft will be launched by Atlas boosters with solid fuel upper stages to penetrate to within 0.4 AU of the Sun.

Under consideration for later periods in interplanetary investigation are Advanced Pioneer spacecraft. These spacecraft would weigh between 400 and 750 pounds and would use a 7,000-pound thrust high energy stage with the Saturn IB/Centaur. These advanced spacecraft would be placed in trajectories which might reach as close to the Sun as 0.2 AU or as far away as 8.5 AU. They would be designed for a lifetime of several years. Instrumentation would be similar to that carried by the Pioneer. The probes going away from the Sun would pass through the asteroid belt in the region from 2 to 3 AU, and it would be of use to study this area extensively with micrometeoroid detectors. The galactic cosmic ray flux could be determined for the first time over large distances in the solar system. Present theories predict that the solar wind excludes large numbers of galactic cosmic rays from the solar system, thereby giving an erroneous and low estimate of the true flux of cosmic rays in the galaxy. If this theory is verified, it will require significant changes in astrophysical concepts. Among the technological advances that would be required for these missions are improvements in thermal control and the development of

radioisotope power supplied. The large 210 foot antennas being considered for the deep space communication network would be required for the more distant missions.

Another exploratory mission now being considered is an extension of the Pegasus micrometeoroid detection satellite shown in Figure 41. This 3,000-pound spacecraft has been designed to be placed in Earth orbit by the Saturn 1, and will be launched early in 1965. With its "wings" extended (96 feet), it exposes an area of 2,000 square feet designed to detect and count micrometeoroid penetrations. An extension of this program now under consideration would use a Saturn IB/Centaur to send a Pegasus spacecraft to the vicinity of the Moon to determine more precisely the micrometeoroid density in cislunar space.

Future unmanned space missions will also include advanced observatories for more detailed study of the Sun. An understanding of the Sun, its behavior, and of the solar particles emitted from it is important to the study of many phenomena of the Earth. The Earth's weather is to a great extent determined by the behavior of the Sun, which is, in turn, quite variable. Figure 42 shows photographs of the Sun at the two extremes of its activity cycle.

The first Orbiting Solar Observatory (OSO 1) was launched in 1962, the second in February 1965. The Advanced Orbiting Solar Observatory (AOSO), shown in Figure 43, will make improved measurements of various solar phenomena during the next solar maximum. The AOSO will weigh about 1,200 pounds, carry about 250 pounds of instruments, and provide significantly improved pointing accuracy. It will also carry larger and more complex instruments to take advantage of the increased pointing accuracy.

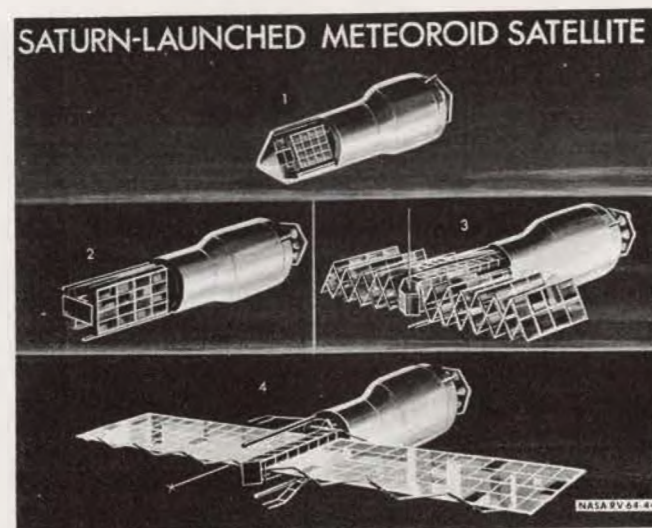


Fig. 41



Fig. 42

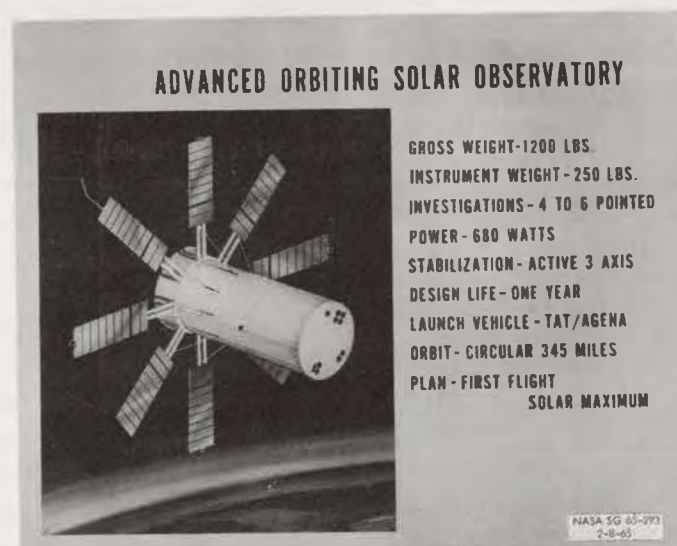


Fig. 43

Shown in Figure 44 is the improvement in resolution that can be obtained by the Advanced Orbiting Solar Observatory over the present capability. As can be seen, resolution will be increased from 1/30 of the solar disk to 1/360 of the solar disk.

One of the most challenging goals of space exploration is the search for extra-terrestrial life. Many scientists think that the planet Mars offers the best possibility of the planets in the solar system, other than the Earth, to support some forms of life.

Planetary exploration will furnish new data on the origin, original composition and evolution of the solar system and will perhaps lead to a better understanding of the origin of the universe.

The problems of planetary flight are substantially more complex than those of Earth orbital or lunar operations. Minimum energy launch opportunities to Mars occur only every 25 to 26 months and the energy required during these opportunities varies with a period of about 15 years.

As can be seen from Figure 45, minimum energy opportunities occur in 1964, 1966, 1969 and 1971 and the required energy increases markedly for the 1973 and 1975 opportunities. Ideal Mars probe velocities corresponding to the minimum energy opportunities are in the order of 42,000 feet per second, as compared with 26,000 feet per second required to attain a 100 mile earth orbit.

To perform a scientifically useful series of missions to Mars will require both orbiting and landing capabilities with a minimum 3-to 6-month spacecraft lifetime at the planet. The lander scientific payload capacity should carry an additional 200 to 300 pounds of instrumentation.

NASA is now initiating the development of a planetary exploration spacecraft (Voyager) having these capabilities. A basic consideration is the adaptability of the spacecraft to the changing requirements of several Mars opportunities, and its capability for growing with technological development, without the need for a completely new spacecraft design.

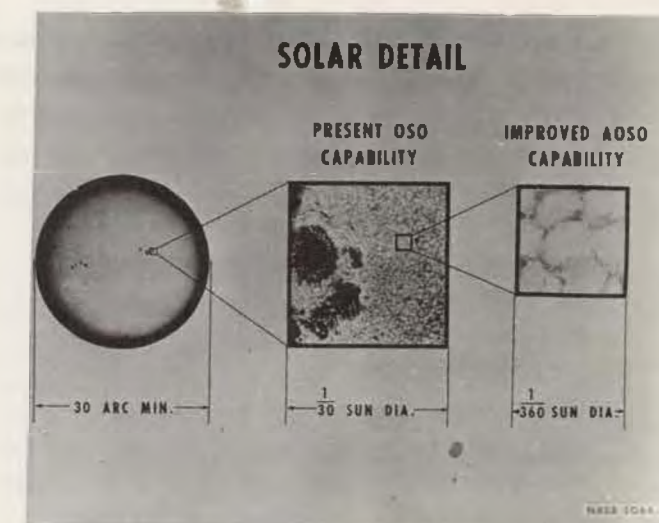


Fig. 44

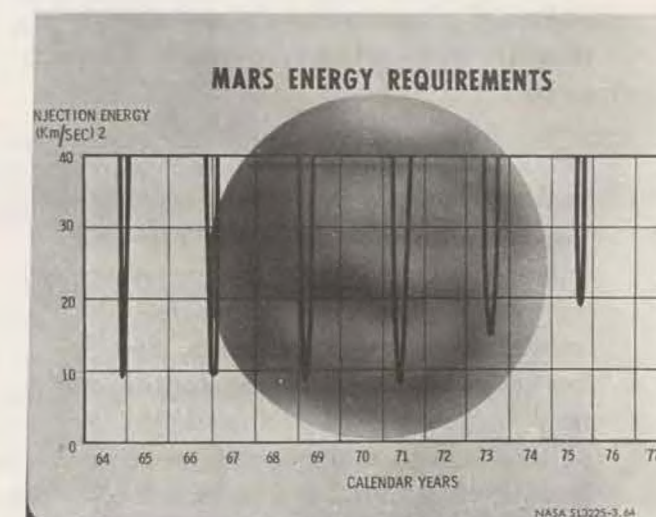


Fig. 45

The Voyager spacecraft concept shown in Figure 46 will weigh up to 10,000 pounds, up to 5,000 pounds of which will be a soft landing capsule (shown at the top center of the figure), and about 2,000 pounds will be allocated to the orbiting spacecraft. The remainder of the weight will be used in retro-propulsion systems for the landing capsule and for the orbiter.

Orbiter instrumentation will include equipment for continuous planetary surface measurements, measurements of atmospheric phenomena such as aurora and day-glow, and measurements of variation in atmospheric composition and thermal structure. The desired data rates from the orbiter are of the order of 3,000 to 4,000 bits per second, which may require a 50-watt transmitter in the spacecraft and 210-foot ground antennas (as compared with the 8-1/3 bits per second to be returned by the Mariner IV).

Figure 47 shows what the lander might look like deployed on the Martian surface. During descent the capsule would make measurements of the state and composition of the Martian atmosphere and would transmit these data to the orbiter for relay to Earth.

Many technological advances would be made incident to the development of the Voyager. In addition to the 210-foot antennas on the ground, larger spacecraft antennas and 50-watt transmitters necessary for communications, and improvements in guidance, control and tracking technology and in engine, propellant storage and mechanical operation technology are required to place the spacecraft in orbit about Mars and to land the instrumentation packages at specified locations on the planet's surface. Reliability also must be improved since even minimum planetary exploration will require a failure-free operating lifetime of almost a year. The landing capsule would require a light-weight radioisotope power source capable of producing several hundred watts. Furthermore, if we are to be assured that the Martian surface would not be contaminated by bacteria carried there from the Earth, all parts of the spacecraft or capsule which might enter the atmosphere or land on the planet must be thoroughly sterilized. Lander instrumentation might include experiments utilizing surface photography, microscopy, light scattering, or radioisotope techniques for detecting micro-organisms or other elementary life forms. Geological and geophysical experiments might also be included utilizing such instruments as a seismometer, a gravity

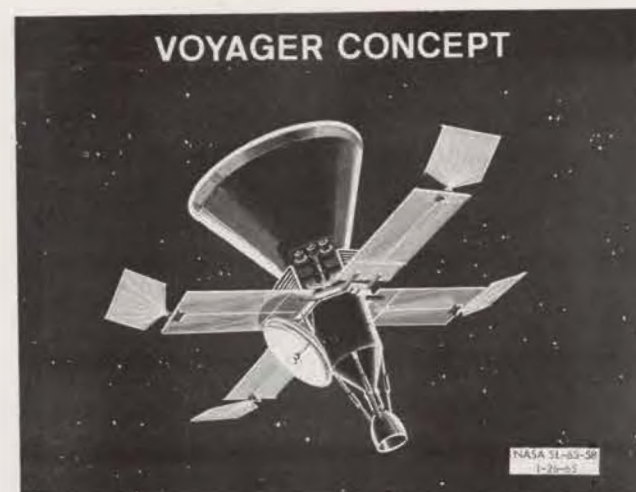


Fig. 46

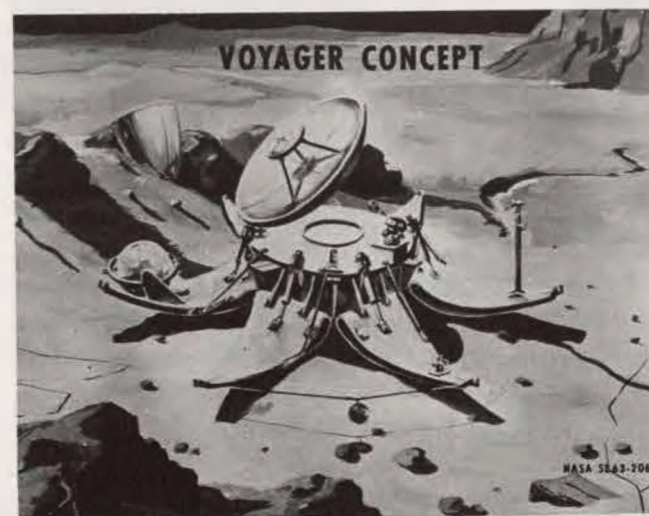


Fig. 47

meter and a petrological microscope; and instruments for measurements of atmospheric composition and profiles. In later versions, the landing capsule might contain an automated biological laboratory and possibly a small roving vehicle designed to make integrated measurements of the Martian biology and ecology.

A careful study of planetary mission requirements has shown that the vehicle most effective for accelerating the Voyager-type spacecraft with the optimum weight and/or volume to the 42,000-foot-per-second velocities required to reach Mars would be a Saturn IB/Centaur combination. Furthermore, the Saturn IB/Centaur would provide in the National Launch Vehicle program a flexible, general-purpose vehicle for planetary and deep space exploration.

Preliminary studies indicate that this Voyager-Saturn IB/Centaur planetary exploration capability could be available in time to take advantage of the 1971 Mars opportunity. It is possible that an initial version of this spacecraft without the soft landing capsule can be developed in time to take advantage of the 1969 Mars opportunity for fly-by or orbital test missions.

Manned Operations

NASA planning for future manned missions seeks to make most effective use of the launch vehicle and spacecraft capability being developed in the Apollo program. It now appears that elements of this capability could be available as early as 1968. The total Apollo program will build up, by 1969, to a capability to launch six Saturn IB vehicles and six Saturn V vehicles annually. The program can also provide up to eight Apollo spacecraft annually for a broad spectrum of space flight missions.

Extended use of the Apollo-LEM system requires an increase in flight duration capability beyond the 2 weeks presently programmed. Initially, the Earth-orbital stay time of the Apollo spacecraft could be extended to one month, and later possibly to 2 or 3 months.

On board power for the extension to one month can be provided by increasing the number of fuel cell banks from three to five to improve the reliability and lifetime. In addition, a space restart capability for the fuel cells will be developed. The weight of the cells and the hydrogen and oxygen reactants will increase from about 2,500 pounds to about 5,000 pounds. These changes will allow up to 1,500 watts to be drawn intermittently for experimental programs.

The increase in the Apollo-LEM system life support capability from 2 weeks to one month can be accomplished by retaining a single gas (pure oxygen) system. Additional equipment such as a debris trap and a catalytic burner will be provided for more positive detection and control of contamination in the cabin atmosphere. Some higher density nutrients will be added to reduce food storage volume requirements. Additional lithium hydroxide canisters for carbon dioxide removal will be installed.

The net weight added to the Command and Service Module to provide the one-month capability, taking into account the added weight of the power and life support systems and the reduction in weight due to removal of fuel and fuel tanks, will be about 2,000 pounds.

For a 90-day capability, the changes to the Apollo-LEM system will be more substantial and will include items such as the following:

- a. Change from a single gas life support system (pure oxygen) to a dual gas system (oxygen and an inert gas, probably nitrogen or helium);
- b. Use of a molecular sieve for recovery of oxygen from carbon dioxide;
- c. Improved cryogenic storage for hydrogen and oxygen;
- d. Provision of an alternate electrical power source such as solar cells or a radioisotope power supply;
- e. Provision of additional food storage;
- f. Provision of added waste management capacity;
- g. Provision of a longer life attitude control system; and
- h. Improvement in the Command and Service Module rocket engine to provide a reliable restart capability after a 90-day storage in space.

The Apollo-LEM system has a large and versatile capability for a variety of missions. The Command Module provides about 190 cubic feet of usable working space. As indicated by the shaded area in Figure 48, 250 cubic feet of unpres-surized volume is also available within the basic Service Module for payloads and/or expendables. This volume is sufficient for flight durations up to one month. In addition, it is possible (though inefficient from the weight standpoint) to extend the duration in Earth orbit up to 3 months by removing the propellant tanks from two additional bays and adding more fuel cells and expendables in that space as shown in outline form in Figure 48.

If additional pressurized volume is required, the ascent stage of the Lunar Excursion Module (LEM) can be used. By removing the LEM ascent engine, its propellant, the LEM life support equipment, and other lunar landing mission equipment, the total available volume can be more than doubled. However, there will be other missions, such as rendezvous and inspection, where the LEM descent engine will be retained so that the space maneuverability of the basic LEM can be used.

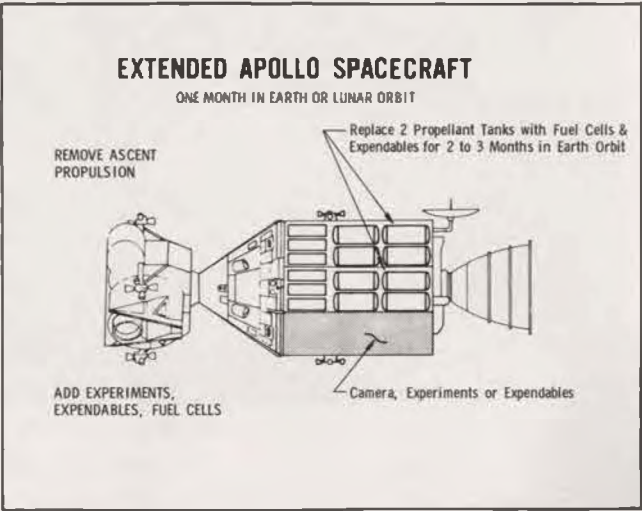


Fig. 48

Some of the possible missions which might be carried out using the extended Apollo capabilities are illustrated on Figure 49. A Saturn IB launch vehicle will provide sufficient thrust for placing one of these spacecraft in a low inclination orbit below the Van Allen belts where the basic problems of keeping men in space for extended periods can be studied, rendezvous and resupply problems can be worked out, and scientific experiments can be conducted.

A Saturn V launch vehicle might be used to place one of these spacecraft into higher inclination or polar orbits for operations which require frequent observation of the entire surface of the Earth. A Saturn V could place one of these spacecraft into a synchronous orbit to carry out experiments which involve manned observations over a given portion of the Earth or which use man to assist in the operation of various experimental systems.

Mapping and surveying of the lunar surface from orbit could be accomplished by injecting the spacecraft into a lunar polar orbit and extending the orbital mission duration to about 28 days. This would permit the entire lunar surface to pass beneath the spacecraft under good lighting conditions.

Figure 50 shows several possibilities for extension of the capabilities of the basic Apollo-LEM system when used with the Saturn IB and Saturn V launch vehicles. It illustrates possible trade-offs between instrument payload and maneuverability for several launch vehicle-spacecraft configurations in various orbits.

For example, the first line indicates the capability of a Saturn IB to orbit an Apollo Command and Service Module and LEM modified for a stay time of 30 days. With such a configuration, a choice would exist between carrying 5,000 pounds of payload with no fuel available for maneuvering, or no payload with fuel sufficient for a total velocity change of 2,000 feet per second which might be used for a 4-degree change in orbital plane. The payload and velocity increment combination shown represent end-points. Various combinations of payload and fuel between these limits are also possible. Although not indicated in the figure, this configuration will support three men for 30 days. The

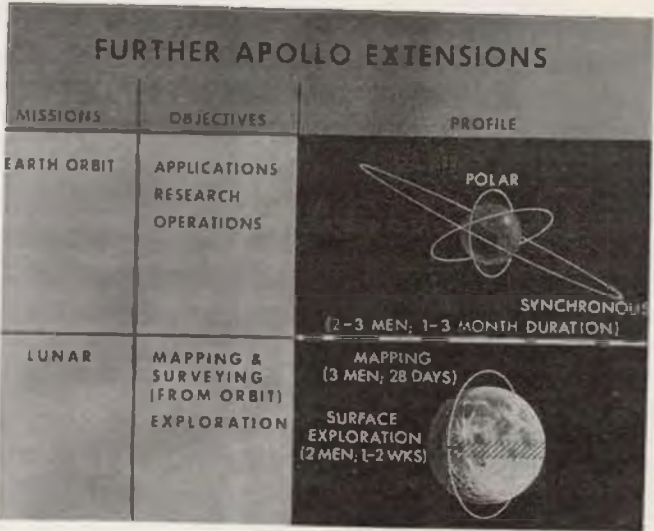


Fig. 49

EXTENDED APOLLO MISSION CAPABILITIES						
MISSION	CONFIGURATION	ORBIT H.M. INCL.	DURATION (DAYS)	PAYLOAD (LBS.)	ΔV (fps)	EQUIVALENT PLANE CHANGE (DEG)
EARTH ORBIT	SAT IB/XCSM/LEM AS	200/30°	30	5,000	0	—
EARTH ORBIT	SAT V/XCSM/LEM ASP	200/30° INITIAL	30	210,000	0	—
EARTH ORBIT	SAT V/XCSM/LEM AS	200/POLAR	30	200,000	0	—
EARTH ORBIT	SAT V/XCSM/LEM AS	200/POLAR	60	12,500	2,000	—
EARTH ORBIT	SAT V/XCSM/LEM AS	SYNCHR/0°	30	9,500	0	—
EARTH ORBIT	SAT V/XCSM/LEM AS	SYNCHR/28°	60	10,000	—	—
LUNAR MAPPING	SAT V/XCSM/LEM ASP	80° POLAR	28	9,500	—	—
LUNAR SURFACE EXPLORATION	SAT V/XCSM/LEM (DUAL LAUNCH)	LUNAR SURFACE	14	2,500	—	—

NOTES: XCSM - APOLLO COMMAND AND SERVICE MODULE WITH ADDITIONAL SUBSYSTEMS AND EXPENDABLES
LEM AS - LEM ASCENT STAGE WITHOUT SUBSYSTEMS, DEPENDENT ON XCSM
LEM ASP - LEM AS PLUS LEM DESCENT STAGE PROPULSION

Fig. 50

lifetime could be extended beyond the 30 days by changing to more efficient subsystems, particularly in the power and life support area. With a two-man crew, the spacecraft lifetime might be extended up to 3 months.

The Saturn V provides a much greater mission flexibility. Line 2 of Figure 50, for example, describes a Saturn V launch configuration in which either a very large payload or fuel for a very large velocity increment could be placed in a low-altitude, low-inclination (about 30 degrees) orbit. The spacecraft configuration consists of an extended Command and Service Module plus a modified LEM ascent stage together with the LEM descent stage propulsion. If all propulsion systems are then used to capacity, this extended Apollo spacecraft would have a capability for a total velocity increment of about 26,000 feet per second which is equivalent to a 60-degree low-altitude orbital plane change. In this configuration the S-IVB stage, Service Module, and LEM descent stage propulsion would all be utilized for plane changes.

Line 3 of Figure 50 describes the capabilities of a spacecraft configuration similar to the basic configuration shown in the first line when launched by a Saturn V. For a 30-day polar orbit mission, 17,500 pounds of payload or fuel can be carried. This launch could be accomplished from the Cape Kennedy launch sites and still remain within the range-safety limits. In this mission, Service Module propulsion would be used during part of the polar orbit injection maneuver.

In the fourth line, the configuration and mission are similar to those previously described, except that a 60-day mission duration is achieved in polar orbit. Here again there is the choice between the maximum mission equipment payload of 12,500 pounds or a 2,000-feet-per-second maneuvering capacity. It may be noted that on this 2-month polar orbit mission the available volume for propellant tankage is sufficient only to provide a 2,000-feet-per-second velocity increment, which does not use up all of the available payload.

The fifth line shows a mission capability in an equatorial synchronous orbit in which the spacecraft would appear to be stationary over a point above the equator. Line 6 describes a similar configuration in a 60-day mission, but with the synchronous orbit achieved at a 28-degree inclination so that an equipment payload of 10,000 pounds can be carried. The two missions of lines 5 and 6 each require Service Module propulsion to achieve orbital injection.

As shown in the seventh line, the extended Apollo spacecraft, equipped with the LEM and its descent propulsion stage, is also capable of carrying about 9,500 pounds of lunar survey equipment in a lunar polar orbit. In this configuration, the added LEM descent propulsion is used for a portion of the lunar orbit injection maneuver in order to leave additional propellant in the Service Module. This additional Service Module propellant is necessary in order to provide a continuous capability to abort from the lunar polar orbit during any of the 28 days of operations.

The bottom line of Figure 50 describes how two Saturn V launches may be used to provide a 14-day lunar surface exploration capability. In the first launch, an unmanned LEM, modified to provide shelter and life support for two men for 14 days, is landed on the lunar surface. The astronauts are landed in a second LEM which will remain in a

quiescent state while the astronauts live in the shelter. At the end of the 14-day mission, the LEM which landed the astronauts is reactivated to carry them back to the Command and Service Module in lunar orbit for the return to Earth. A discussion of the returns to be derived from such a mission is presented later.

Shown on Figure 51 are the classes of experiments that could be carried out during extended earth orbital missions. The three basic classes are Space Sciences, Earth-Oriented Applications and Support for Space Operations.

Studies of the effects of the space environment on man's circulatory and respiratory systems, metabolism rate, and nerve, muscle and bone tissues are of interest not only because of their necessity for further manned space operations, but also because of the application they might have to the understanding of human physiological processes. Experiments would also determine the effects of prolonged weightlessness and confinement on human behavior and psycho-motor performance.

Other biological experiments could be run to determine the effects of zero gravity and radiation upon the growth rate and mutation rate of bacteria. For example, Hela cells might be grown in space to determine whether zero gravity affects animal tissue growth at cellular levels.

An important experiment which might be carried out in an extended Apollo spacecraft would involve a highly instrumented primate. The instrumentation would include deep brain probes and cardiovascular implants, and a variety of metabolism experiments. The primate would also have a separate life support system, so that the effects of various atmospheres on the body functions could be studied. The astronauts would observe the behavior of the primate and, in addition, might conduct various experiments in which the primate would receive injections. Behavioral experiments would be conducted to determine both weightlessness and biorhythm effects.

Extended Apollo missions will provide an opportunity for proving out capabilities for various space operations such as rendezvous or orbit-change maneuvers. Techniques for extra-vehicular activities as may be needed in external repair and maintenance of spacecraft, or in erection of large space structures, such as antennas or solar energy collectors, might also be investigated.

Similarly, many of the problems that will be associated with orbital launch of inter-planetary spacecraft can be simulated with the extended Apollo. Countdown and checkout procedures can be exercised, induced perturbations studied, fuel handling and transfer techniques can be tested, and inspection and repair techniques developed.



Fig. 51

In addition, the extended Apollo spacecraft could be used as a "truck" to carry complete scientific satellite payloads into space where they could be removed from the Service Module, checked out and adjusted by an astronaut, and left in orbit to transmit data in the conventional manner.

With their astronauts, Apollo extensions will provide special capabilities which the meteorological community can adapt to meteorological experiments designed to further our understanding of the behavior and structure of the Earth's atmospheric envelope. Scientifically significant experiments in the fields of photographic and visual observations, spectrometry, radar, far-infrared sensing, and television are definitely feasible. These meteorological experiments can exploit the spacecraft advantages which permit the in-flight modification of experiments, equipment design simplicity, in-flight testing of experimental concepts, module-to-ground communication, data recoverability, and the observation of infrequent but meteorologically significant phenomena.

Manned spacecraft could also determine the feasibility of carrying out synoptic and multi-sensor mapping of the earth. Polar-orbiting spacecraft would be desirable for these mapping operations since the entire earth could then be viewed in 24 hours. These operations might provide a comprehensive earth resources survey and inventory covering the fields of agriculture, forestry, geology, hydrology, oceanography and geography. Activities in these areas would be developed in close coordination with other government agencies and departments.

In the field of astronomy, preliminary studies are underway to determine the feasibility of adapting the Orbiting Astronomical Observatory to manned operation. These modifications might include the use of film which, in many cases, has great advantages over vidicon tubes or other electronic sensors. Each square centimeter of film contains over 10^9 bits of information--more than can be telemetered to Earth in one hour. Astronauts could also maintain the spacecraft and repair and replace instrument packages. This mission would develop the techniques that might be used in later missions involving space stations and telescopes as large as 100 inches in diameter which might be assembled in space.

In the category of advanced technology and subsystems, small critical spacecraft components or subsystems can be tested in a true space environment before they are committed to use in longer duration missions. For example, some of the key components which might be used for recovering oxygen from carbon dioxide in Earth orbiting space stations, lunar bases, or manned planetary missions involve processes which have not yet been tested in a zero-gravity environment. Such tests can be conducted in a manned spacecraft where the presence of man will provide an ability to observe, adjust, and maintain the test and to make preliminary data analyses.

Many basic questions regarding behavior of liquids, solids (as regards crystal growth, for example), and gases under zero-gravity conditions could be answered by simple tests which can be carried out aboard the spacecraft. Results of such experiments would be of fundamental scientific interest and would also be useful in the design of fuel tanks and fuel pumping systems for use under zero-G conditions.

As noted earlier, another extension of the Apollo system involves providing additional stay time on the lunar surface by utilizing the supply capability of the Lunar Excursion Module.

Among the returns to be derived from extended manned exploration of the Moon, one of the first items to be noted is the acquisition of new knowledge of the origin of the Moon and the additional new knowledge which this would provide relative to the origin and early history of the Earth. For example, answers might be expected to fundamental questions such as whether the Moon was once originally part of the Earth which escaped during the Earth's earlier history, whether it was captured by the Earth after having been formed in some other place in the Universe, or whether it was formed at the same time as the Earth out of the same primordial cosmic dust.

The instruments, equipment, and additional life support elements required for extended exploration would be carried to the lunar surface by an unmanned version of the LEM, illustrated in Figure 52, designed to carry equipment and supplies in place of the astronauts and the ascent propulsion motor and its fuel. This vehicle would be landed under remote control at a suitable location on the Moon's surface, and, after its safe landing, another Apollo vehicle carrying two astronauts would land in the same location. The astronauts would then unpack the equipment carried by the automatic LEM, and proceed to set up instruments and carry out various scientific experiments.

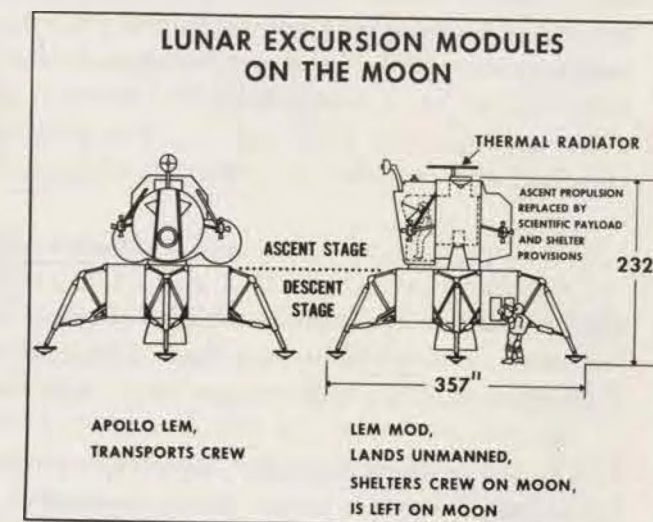


Fig. 52

As presently foreseen, these surface missions could take several forms ranging from those in which the astronauts are limited to the area that they can cover on foot in their spacesuits to later missions in which they might be equipped with a small roving vehicle which could extend their range to several miles.

In addition to shelter and life support equipment, the unmanned LEM can carry as much as 2,500 pounds of equipment and scientific instruments. This equipment might include a lightweight drill which the astronauts could operate while on the lunar surface. This would permit the taking of core samples and the logging of the hole which would be invaluable to both geological, geophysical and biological investigations.

Geologists would be able to determine the existence and composition of stratification layers on the Moon. Biological analysis of these core samples would be useful in determining if life forms presently exist or existed in the past on the Moon. Also, temperature measurements in the bore hole would furnish thermal information on the lunar interior.

In addition to taking core samples which they would return to Earth, the astronauts could place self-contained scientific instrument packages in the vicinity of their landing sites. These packages, which would transmit their data directly to Earth, might include seismic detectors, gravimeters, magnetometers, solar particle radiation detectors, and large-area micrometeoroid detectors.

Experiments to determine the feasibility and the potential benefits that might be accrued by using the Moon as a base for astronomy, both optical and radio, could be conducted on these missions. Very low frequency radio emissions could be received by an antenna on the Moon, a scientific investigation made impossible on Earth by the ionosphere. Additionally, the high (10^{-13} torr) vacuum anticipated in the vicinity of the Moon provides an environment not attainable on Earth in which to conduct experiments.

In later missions the equipment landed might include a small, open, roving vehicle which would permit traverses of several miles. During these traverses, seismic profiles could be recorded by arranging geophones and emplacing explosive charges at selected points, continuous profiles of the gravitational and magnetic fields could be obtained, outcrops exposing the lunar stratigraphy and contacts between geologic units could be visited for close-up inspection and sampling, and continual measurements could be made on the chemical and radioactive properties of the surface.

Launch Vehicles

With respect to the launch vehicles required for the missions to be undertaken in the next few years, a need for mating the Centaur to the Saturn IB and a requirement for a new 7,000-pound thrust high energy stage have been indicated.

NASA is now developing the Centaur hydrogen-oxygen propulsion stage for use with the Atlas launch vehicle in the Surveyor program. Studies have shown that this Centaur stage is also close to optimum for developing the full payload capability of the Saturn IB for launching planetary payloads. Further, it appears possible that the Centaur can be mated to the Saturn IB without major modifications to either the Centaur or the Saturn IB upper stage.

The Saturn IB/Centaur combination shown in Figure 53 is needed as a general purpose space exploratory vehicle for missions such as the 10,000-pound Voyager spacecraft to Mars, for sending advanced Pioneer spacecraft close to the Sun and out beyond the orbit of the asteroids and for sending the Pegasus micrometeoroid spacecraft to the vicinity of the Moon. It might also be used to place heavy payloads, such as the direct broadcast TV satellite, in synchronous orbit. The present program is developing a capability which would permit two launches from a single launch pad during a Mars or Venus opportunity. This vehicle might also be used for propelling two light-weight spacecraft, such as two advanced Applications Technology Satellites, on a single launch.

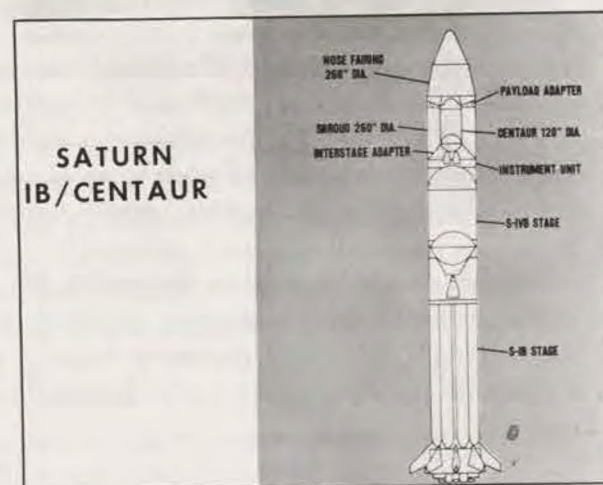


Fig. 53

The 7,000-pound thrust high energy stage will be developed to fit on top of the Centaur and thus could be added to the Atlas/Centaur or the Saturn IB/Centaur. This stage might also be incorporated as the retro-propulsion system to place the Voyager spacecraft into a Martian orbit. When used with the Atlas/Centaur, it could propel heavier science and application satellites, such as the Orbiting Geophysical Observatory or FM Broadcast satellites, into synchronous or stationary orbits, or send lighter spacecraft to within .3 AU of the Sun or out to 4 AU.

Added to the Saturn IB/Centaur, this high energy stage can perform missions designed to reach the more distant planets, escape from the solar system, or explore space near Mercury and the Sun. It will also allow initial exploration of the solar system outside the ecliptic plane.

Technology

Technological advances required for the intermediate missions will be an outgrowth of present efforts. Manned missions for durations of 30 days will require improvements in fuel cells, and, for periods longer than 30 days, will require power sources producing several kilowatts. The Voyager mission to Mars will require a guidance and control system capable of landing a capsule within 250 miles of a pre-selected site on Mars, a communications system capable of transmitting at least 3,000 bits of information per second over the 250 million-mile Earth - Mars conjunction distance, reliability sufficient to insure 3- to 6-month spacecraft lifetime at the planet after a 7-month trip through space to the planet, and sterilization techniques that can insure a probability of less than one chance in 10,000 of contaminating Mars. Life support systems capable of supplying the needs of three men for one to 2 months will be required, as will stabilization systems capable of stabilizing a synchronous altitude satellite within plus or minus 2 degrees and of pointing a satellite such as the Advanced Orbiting Solar Observatory at a spot on the Sun $1/360$ th of the Sun's diameter.

Research and technology development programs should be planned not only to supply the technology specifically needed by the current and intermediate flight missions, but also to increase the already broad base of fundamental knowledge and understanding. A broad program of this sort makes possible a continuous and accurate assessment of what should be and what can be done in space at any time, and provides the flexibility which is needed to permit major new space flight programs to be undertaken, or existing programs to be redirected, on short notice. Such a program often provides unforeseen, valuable, new methods of solving difficult technical problems.

Thus, for the near future, the research and technology program must include those developments in launch vehicle and spacecraft technology which provide a basis for the selection and accomplishment of the missions to be undertaken in the more distant future. These are discussed in the next section, together with a survey of possible future missions.

The intermediate missions which might be undertaken within the next several years, as discussed above, are believed to serve a threefold purpose of (1) meeting national objectives in space, (2) effectively using existing capabilities, and (3) providing a solid base for undertaking those longer-range, advanced missions which might be undertaken within the next several decades.

V. LONG-RANGE AERONAUTICAL AND SPACE DEVELOPMENTS

The concluding portion of this discussion will be a review of the advanced developments in aeronautics, satellite applications, manned and unmanned space exploration, and launch vehicles which we believe will provide the foundation for the space program of the more distant future.

Many of the longer-range developments listed in Figure 54 call for extreme advances in technology that cannot now be clearly foreseen. However, the rapid technological advances of recent years, together with steps that are clearly possible, provide confidence that the work can be accomplished.

We further believe that these kinds of advances not only can be made, but will be made, if not by the United States, then by Soviet Russia, or possibly by some other nation. Further, if vigorous, intelligent, well-planned and well managed programs are pursued, such advances can be made in an orderly progression without crash programs or excessively expensive efforts.

Aeronautics

In the field of aeronautics, research similar to that now underway on the supersonic transport will probably be carried out to develop the technology for hypersonic transports. These hypersonic airplanes are to travel at Mach 6, 7, or 8 and to have ranges of about 6000 to 8000 miles. The technology for hypersonic transports will also be applicable to reusable first-stage boosters and orbital transports.

One concept of a recoverable orbital transport is shown in Figure 55. In this concept, the larger vehicle would take off in a conventional manner and accelerate to a hypersonic velocity. At this time, the smaller vehicle would separate and accelerate under its own power to orbital velocities to deliver men and cargo to and from orbiting space stations, or to carry out various other scientific or military missions in space. Both vehicles would land conventionally.

A decision to develop such a vehicle is not anticipated in the near future, but the development of the propulsion and aerodynamic technology which will ultimately be needed is being undertaken. For example, the

LONG-TERM DEVELOPMENT	
AERONAUTICS HYPERSONIC TRANSPORTS RECOVERABLE ORBITAL TRANSPORT COMMERCIAL V/STOL AIRCRAFT	MANNE SPACE EXPLORATION CONVENTIONAL TAKE OFF AND LANDING OF SPACE VEHICLES FLEXIBLE EARTH ORBITAL OPERATIONS LARGE PERMANENT SPACE LABORATORY MOVING LUNAR VEHICLES AND LUNAR BASES PLANETARY EXPLORATION
SATELLITE APPLICATIONS DIRECT TV BROADCAST NAVIGATION & TRAFFIC CONTROL CONTINUOUS GLOBAL WEATHER OBSERVATION	LAUNCH VEHICLES AND PROPULSION 1 MILLION POUNDS IN EARTH ORBIT RECOVERABLE BOOSTERS NUCLEAR ENGINES ELECTRIC PROPULSION
UNMANNED EXPLORATION PROBES & LANDERS TO DISTANT PLANETS SOLAR PROBES GALACTIC PROBES	TECHNOLOGY NUCLEAR & ISOTOPE POWER SUPPLIES (MEGAWATT) GUIDANCE & CONTROL (CONTROLLED LANDINGS AT DESIRED LOCATIONS ON OTHER PLANETS) COMMUNICATIONS (WIDE BAND COMMUNICATIONS WITH PLANETARY VEHICLES) STABILIZATION PERMANENT LIFE SUPPORT SYSTEMS RELIABILITY

Fig. 54

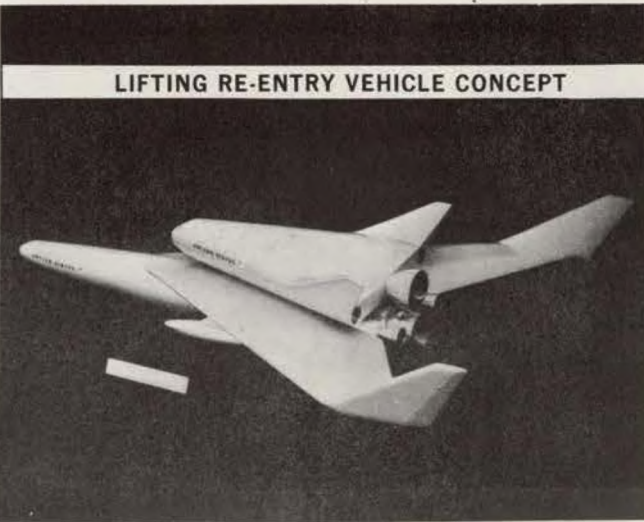


Fig. 55

hypersonic air breathing hydrogen-fueled engine of the type to be tested on the X-15 might be applicable to the larger vehicle. Studies and experiments are likewise under way on lifting reentry bodies similar to the "piggy-back" vehicle. NASA may also propose in the future to develop an experimental manned orbital reentry vehicle of this type which would be used to develop the technology for lifting vehicles reentering the Earth's atmosphere at orbital velocities.

Satellite Applications

Among the more distant future developments in space exploration might be satellites in stationary orbits which broadcast television programs directly to viewers, such as that shown conceptually in Figure 56. This satellite would transmit about 10 kilowatts of power focused into a 3-to 5-degree beamwidth. This would permit coverage of an area about the size of India or western Europe. Such a satellite would require an orientation accuracy of plus or minus 2/10 degree with respect to the Earth and a 35-kilowatt power source that might be a SNAP-8 type nuclear supply. The satellite would weigh about 9600 pounds and would require a Saturn IB/Centaur launch vehicle.

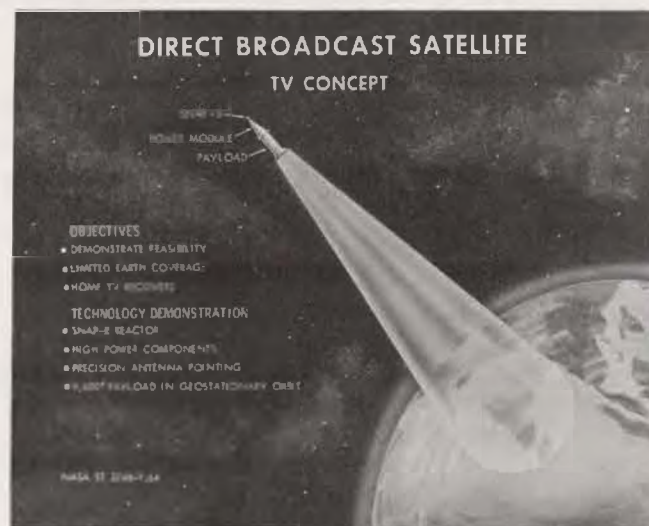


Fig. 56

Global navigation systems which could pinpoint the location of ships and aircraft and display this position information not only to the ships and aircraft themselves, but to other control and monitoring stations on the ground as well, could be developed also. Similarly, continued improvement of satellite meteorological systems should lead ultimately to routine continuous quantitative measurement of the weather over the entire surface of the Earth. Much of the technology needed for long-range developments such as these will be developed and proved by the missions to be undertaken within the next few years.

Unmanned Exploration

In the period beyond 1975, probes will probably be used initially to explore most of the more distant bodies in the solar system and to determine the space environment out of the plane of the ecliptic. Satellites in near-Earth orbit will be used to make detailed studies of active regions on the Sun and to monitor fluctuations in solar activity and in solar and galactic cosmic ray flux. Voyager class spacecraft will be flown to Mars and Venus at most opportunities, and unmanned spacecraft to explore the more distant planets, the asteroids and comets will be started.

New spacecraft will be developed for distant planet and asteroid missions utilizing many of the components and technologies that have been or will be developed in the Voyager programs. Spacecraft to be used for fly-by missions to comets, asteroids, and the planet Mercury will make measurements of the solar wind, interplanetary magnetic fields, and micrometeoroid flux during their flight through space. The missions to comets would also carry instruments to measure electron temperatures, to search for water and carbon dioxide vapor, and to collect

and analyze dust particles. A fly-by mission to the planet Mercury or to an asteroid would carry television cameras for inspection of the surface, magnetometers and particle detectors to search for magnetic fields and trapped particle radiation, and radiometers to make surface temperature measurements. Of particular interest is the possibility of the existence of warm temperatures on the backside of Mercury. Characteristic velocities for these missions range from 40,000 to 48,000 feet per second.

For Jupiter missions, it would be desirable to have a spacecraft weighing at least several thousand pounds. Advanced versions of this spacecraft might carry a retro-propulsion system similar to the one planned for the Voyager which could decelerate the spacecraft to Jovian orbital velocity. Ideal velocities for this mission range from 52,500 feet per second to 55,000 feet per second. Trip times to Jupiter would range from 500 to 600 days during the minimum energy launch dates that occur in the 1972-75 time period and again in the 1984-88 time period.

Instrumentation for this mission would be similar to that carried on other planetary missions and would make measurements of magnetic fields and trapped particle radiation, and take television pictures of the planet's surface.

This spacecraft could be launched by a Saturn IB/Centaur or Saturn V. Communication distances for these missions would range up to about 400 million miles. The more distant missions would require significant advances in our present communication capability if meaningful scientific data are to be returned. Communications system improvements might include larger antennas and more powerful transmitters on the spacecraft and larger receiving antennas on the Earth, probably using phased array techniques. Improved coding techniques would also be valuable to missions of this type. Radioisotope sources might be used for electric power.

Manned Space Exploration

As an outgrowth of the longer duration Apollo missions discussed earlier, a larger manned orbiting laboratory, similar to the one shown in Figure 57, might be developed. This spacecraft would accommodate six to nine men and remain in orbit for possibly 5 years. Re-supply vehicles and rendezvous techniques would have to be developed to provide for crew rotation and for delivery of supplies and equipment. This particular laboratory concept would also contain a centrifuge, should it be found essential for reconditioning crew members to withstand the effects of gravitational fields after periods of weightlessness. It would also provide much roomier quarters with a shirt-sleeve environment for conducting a wide variety of experiments in space.

Some of the technological advancements which would be made in the development and operation of manned orbiting laboratories



Fig. 57

are listed in Figure 57. These include:

- The development of dependable closed life support systems which recover oxygen and water from waste materials;
- The study of the effects of long-term (up to one year or longer) weightlessness on man and, as mentioned, previously, the development of a human centrifuge or other techniques, as may be necessary to compensate for the prolonged effects of zero gravity;
- The development of nuclear, solar, or other types of electrical power systems capable of supplying several kilowatts of power for operating the laboratory and its experimental equipment; and
- The development of spacesuits to permit working outside the spacecraft, long-life reaction control systems for controlling and maintaining the spacecraft's attitude, and other systems such as parachutes and solid rockets which will work dependably after "soaking" for extended periods in the hard vacuum of space.

The Saturn IB would be adequate for placing this manned laboratory in low inclination orbits, while the Saturn V would be used for high inclination, polar, or stationary orbits.

A large telescope might be placed in orbit in conjunction with these laboratories. The extreme stability requirements of a large telescope would dictate that it not be rigidly attached but rather that it be tethered to the laboratory. This would allow the astronauts from the laboratory to change film, modify or change experiments, or perform any repairs that might be required.

The advantages of having telescopes above the Earth's atmosphere are that resolution can be improved and that observations can be carried out in the infrared and ultraviolet wavelengths that do not penetrate the Earth's atmosphere. The best resolution obtained by the 200-inch telescope on Mount Palomar, under ideal viewing conditions, is about 0.3 seconds of arc. A 100-inch diameter telescope which might be used in space with the manned orbiting laboratory would improve this resolution to .01 to .02 seconds of arc -- a factor of better than 10.

Although the resolutions shown in Figure 58 do not correspond to the resolutions of the telescopes just discussed, the comparative improvement in resolution illustrated here is approximately equivalent to that of a 100-inch telescope in space over a 200-inch telescope on Earth.

Following the development of a manned orbiting research laboratory capability, a large manned orbiting research laboratory might then be developed, two possible configurations of which are illustrated in Figure 59. The configuration on the left illustrates how a large laboratory might be assembled in

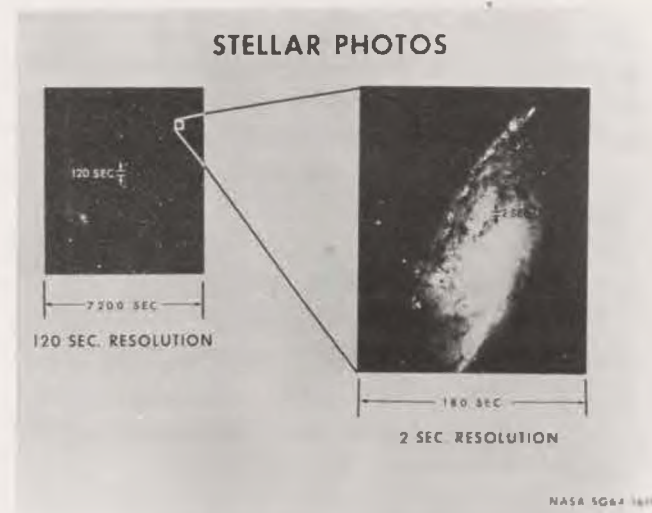


Fig. 58



Fig. 59

space using four of the six-to nine-man medium size orbiting laboratories which were discussed previously. The configuration on the right might also be assembled by joining together a new center section plus the three separate laboratories which comprise the "spokes" of the larger laboratory. Artificial gravity could be provided for the crew in laboratories such as these by rotating them about their axes.

Large laboratories of this sort would make use of both Saturn IB and Saturn V class vehicles and will require many major technological advances in reliability and in electrical power supplies, life support and other systems, as well as a much better understanding of the physiological and sociological factors in-

volved in keeping man in space for extended periods of time.

Long range developments in lunar exploration will, of course, be determined to a large extent by what is learned from on-going Ranger, Lunar Orbiter, Surveyor, and Apollo programs, and from extended Apollo programs including use of the LEM truck for extended lunar stay time. It is also expected that the Moon would be explored in considerably greater detail through the use of roving vehicles for transporting men and equipment on the Moon's surface and through the establishment of semi-permanent or permanent lunar bases. In addition, these bases might be used as optical and radio astronomy observatories.

Manned exploration of the Moon beyond plus or minus 10 degrees of the lunar equator would require development of a direct flight capability rather than lunar orbit rendezvous. This capability might be provided by chemically uprating the Saturn V, by introducing a chemical fourth stage to the Saturn V, or by replacing the third stage of the Saturn V with a nuclear stage, as will be discussed later under the heading of Launch Vehicles and Propulsion.

As illustrated in Figure 60, an unmanned lunar excursion module may be used to land a lunar surface transportation vehicle, identified here as a lunar "jeep". This vehicle would carry sufficient food, water and oxygen, and provide shelter and scientific equipment needed for extended tours of the lunar surface. A second lunar excursion module would be used to transport the crew to the Moon. The crew members could then use the "jeep" to transport themselves and their needed scientific instruments and equipment to more remote spots for a much more extensive exploration. Preliminary studies indicate that a 3-ton "jeep", which could be delivered to the lunar surface by Saturn V, might carry enough fuel and life support



Fig. 60

supplies to travel up to 300 miles and to sustain two men for possibly 2 weeks. Here again, it is obvious that major advances in technology will be required.

These include:

- a. Electrical power sources capable of producing many kilowatts;
- b. Spacesuits flexible and durable enough to allow climbing in and out of the "jeep" and working on the lunar surface;
- c. Reliable long-time storage of cryogenic supplies; and
- d. Scientific instruments specifically developed for use on the lunar surface.

These advances are in addition to the basic engineering and technical problems involved in the development of the vehicle itself which must be capable of traveling over unfamiliar and unimproved terrain in the hard vacuum of the lunar surface.

Much further in the future, it may be desirable to establish a semi-permanent or permanent lunar base such as the one depicted in Figure 61. Various modules containing food, water, oxygen, and supplies, and other modules providing electrical power, communication facilities, and laboratory or shop facilities, might be delivered to the Moon's surface, one at a time, by using Saturn V class rockets as direct-flight logistics vehicles to establish a lunar base or colony of whatever size may be desired.

One long-range possibility of particular interest to radio astronomers would be the construction of very large radio astronomy antenna arrays or telescopes similar to the ones in Figure 62. One of the Moon's craters might serve as the foundation of a large parabolic or spherical antenna similar to the one at Arecibo, Puerto Rico. The backside of the Moon appears especially useful for this purpose, since there would be no man-made radio noise to interfere with, and no ionosphere to attenuate, low-level radio signals coming in from outer space.

Possibly the most challenging long-term goal of the entire space program is manned exploration of the planets -- especially of the planet Mars. One of the most significant events in the history of mankind may well occur when man first sets foot on the planet Mars, possibly to view

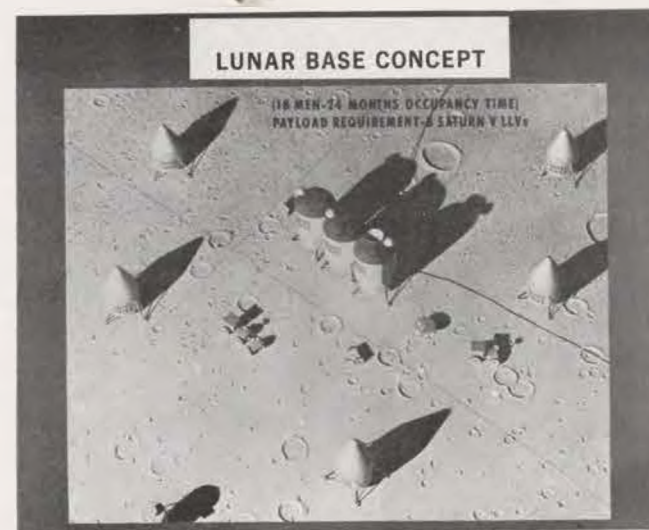


Fig. 61



Fig. 62



Fig. 63

plant and animal life unlike anything ever seen on Earth. Although tremendous strides in space technology and many preliminary unmanned and manned missions of various types must be carried out before manned exploration of Mars can be seriously considered, some preliminary study has been given to such a mission.

Figure 63 summarizes some of the results of our thinking to date. The mission would likely include: (1) an initial rendezvous and assembly of the spacecraft in Earth orbit, (2) the trip of about 200 days through space from Earth to Mars, using nuclear propulsion, (3) landing of a Mars excursion module (similar to the concept of the LEM) and exploration of the planet's surface, (4) as-

cent to orbit for rendezvous with the orbiting portion of the spacecraft, and (5) return of the explorers to Earth.

The spacecraft would be assembled in Earth orbit before departure for Mars and would weigh millions of pounds, the exact weight depending upon factors such as the type of propulsion used, whether or not the thin Martian atmosphere can be depended upon for significant braking, and the year of the flight. In any event, as a practical matter, it appears that launch vehicles considerably more powerful than the Saturn V will be required to carry the necessary spacecraft hardware into Earth orbit.

In the propulsion of the spacecraft from Earth orbit to the planet, a clearly defined need arises for much more efficient propulsion, such as might be provided by nuclear rocket engines and by electric propulsion systems. For a Mars mission, the weight of a nuclear propulsion system would be much less than that of a comparable chemical system. Consequently, use of a nuclear stage for the Earth-orbit-to-Mars phase would greatly reduce the weight which must initially be placed in Earth orbit. It has been estimated that use of a nuclear stage for Earth-orbit-to-Mars propulsion would reduce the weight required in Earth orbit by at least 2 to 1 and possibly much more. The combination of nuclear rockets and electric propulsion could result in an even more significant weight reduction.

Many major technical advances are necessary before manned planetary missions can be undertaken. In addition to the development of more powerful launch vehicles and the perfection of nuclear rocket engines, these will include:

- a. Development of dependable life support systems to provide food, water, fresh and uncontaminated cabin atmosphere, and waste elimination for multi-man crews and for mission durations of 2 to 3 years;
- b. Electrical power systems capable of supplying many kilowatts of power for long periods;
- c. Much higher capacity communication systems; and

d. More complete knowledge of the interplanetary environment is also needed to assure the design of safe, (i.e., adequately sealed and shielded) spacecraft structures. The gathering of these data will begin with the Mariner flight this year and continue with Voyager flights.

Launch Vehicles and Propulsion

With regard to the launch vehicles to be required by long-term future missions of the types listed here, most of the missions could, with one or two notable exceptions, be carried out using the available family of launch vehicles, assuming that the performance of these vehicles will be uprated as new propulsion technology is developed. The major exceptions are the ones noted in the discussion of manned lunar exploration beyond the equatorial region and manned planetary missions.

It has already been noted that a spacecraft weighing several million pounds would have to be placed in Earth orbit for a manned planetary expedition. Realistic evaluations of spacecraft weight indicate that a post-Saturn launch vehicle capable of placing on the order of a million pounds in Earth orbit will be needed. Some of the propulsion technology efforts now under way that would be applicable to development of such a launch vehicle are shown in the next figures.

Figure 64 shows the M-1 engine which is planned as a 1.5 million-pound thrust engine using hydrogen-oxygen propellants providing a specific impulse of over 400 seconds.

Also being investigated are large solid propellant motors. Shown in Figure 65 is a drawing of a "half-length" version of a 260-inch solid fuel rocket motor. It is about 70 feet long. The half-length motor would weigh about 1.7 million pounds and could develop about 3 million pounds of thrust. A full-length motor would deliver 6 to 7 million pounds of thrust for over 100 seconds of operation.

With regard to nuclear rocket propulsion two uses have been mentioned: manned planetary exploration and direct flights of manned spacecraft to the Moon. For a manned Mars mission, the initial weight in Earth orbit using nuclear propulsion would range from 1 1/2 to 5 1/2 million pounds, depending upon such factors as year of launch and mission size. Using chemical propulsion the spacecraft weight could vary between 3 and 24 million pounds.

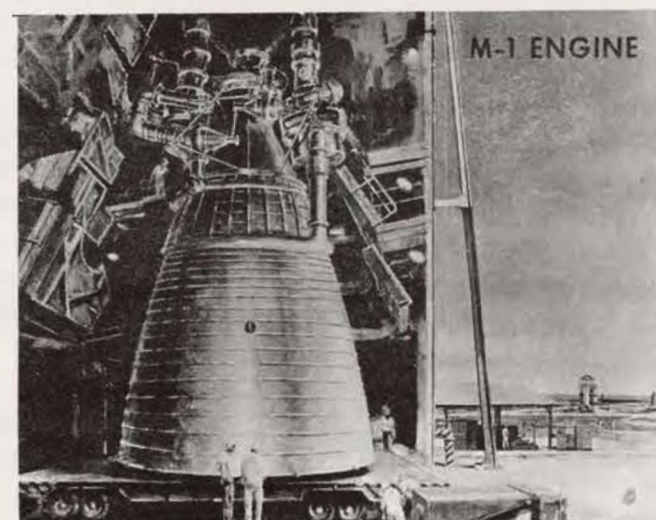


Fig. 64

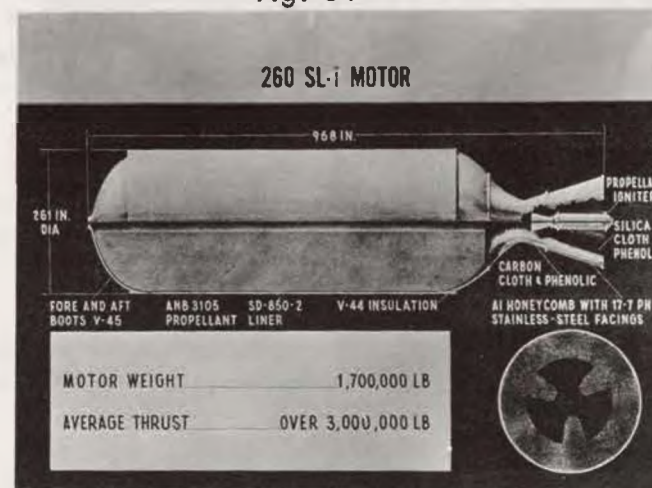


Fig. 65

A major point to emphasize, in addition to the large weight saving by the use of nuclear rocket propulsion, is that the limitations on spacecraft weight linked to changes in mission year, mode of flight accomplishment, and payload requirements are far less with nuclear rocket propulsion than with chemical propulsion. It is, therefore, conceivable that a single nuclear propelled spacecraft could be developed to accomplish the Mars mission at every opportunity with sufficient margin to assure that changes in the mission parameters will not result in aborted development efforts, major program changes, or restricted mission opportunities.

NASA and the Atomic Energy Commission have underway a joint program aimed at the development of nuclear rocket propulsion so as to be able to utilize the high performance of nuclear rocket systems and the improvement in vehicle payload capabilities that would result from their use in a wide variety of high-energy increment missions in space, such as manned planetary landing missions, direct flight lunar missions, and unmanned missions to the more distant regions of the solar system.

Two KIWI reactors and one NERVA reactor were tested successfully in 1964 at high power and temperature conditions. Figure 66 shows a picture of the KIWI reactor before its first power operation late in August 1964. This reactor has an outside diameter of about 4 feet and excluding the nozzle, it is about 6 feet long. It is designed for a power of about 1000 megawatts, or 50,000 pounds of thrust.

Figure 67 is a picture taken during the test operation of the KIWI reactor. During this test, the reactor was operated for a total of approximately 12 minutes -- 8 minutes at the maximum power conditions. The duration of the test was limited only by the available supply of liquid hydrogen. The vacuum or altitude specific impulse equivalent to the operating conditions achieved in this test was about 740 seconds with an equivalent altitude thrust of approximately 51,000 pounds.

On September 10, 1964, this reactor was rerun at full power for another 2 1/2 minutes, demonstrating the ability of these systems to be re-started. On disassembly, the reactor was found to be in excellent condition; however, some design and fuel element

KIWI-B4E REACTOR AT TEST CELL C



Fig. 66

KIWI-B4E IN OPERATION



Fig. 67

improvement is still required in the peripheral area of the reactor core. The tests demonstrated conclusively that the mechanical vibration problems encountered in previous nuclear rocket reactor tests had been successfully overcome.

These tests of the KIWI reactor were followed on September 24 by high power tests of the NERVA reactor to a vacuum equivalent specific impulse of approximately 765 seconds and a thrust of about 57,000 pounds. This reactor is the flight version of the KIWI reactor and will be used in the NERVA flight engine programs.

These recent successful reactor tests have demonstrated the high performance capabilities of nuclear propulsion systems and provide a high level of assurance that nuclear rocket propulsion can be relied upon for application in future space missions and vehicle designs.

It is important to recognize that the current AEC-NASA nuclear rocket program is providing the component and system technology that is required to develop engines of many required thrust levels. Operating limits and characteristics are being explored so that reliable and successful flight systems can be developed. The long lead times required in flight system development make it essential that the technology be available in advance of the specification of future missions.

Work is also underway on reactors that would be needed in higher power engines for the manned Mars mission. These higher power (5000 megawatt, or 250,000 pounds of thrust) and larger diameter reactors are now under investigation at the Los Alamos Scientific Laboratory as part of the AEC-NASA Phoebe program. A cluster of engines using these reactors would provide thrust sufficient for an Earth-orbit departure stage for a manned Mars mission. Single engines of this type could be used for Mars orbit entry and for the Mars orbit departure. The lower thrust, smaller diameter and weight NERVA engine (based on the KIWI-NERVA reactors already tested), would, however, provide some performance advantage if used in the Earth return stage.

In addition to the need for nuclear propulsion for the manned Mars mission, extensive lunar exploration or establishment of lunar bases may require the development of a direct-flight landing capability. At present, the Saturn V is capable of carrying a 28,000-pound payload directly to the lunar surface. It is estimated that the minimum weight required for direct manned flight and return is 31,000 pounds, as indicated by the horizontal broken line at the bottom of the cross-hatched area in Figure 68.

A Saturn V vehicle using a nuclear-powered third stage would provide a capability for landing approximately 45,000 pounds directly on the Moon. This 14,000 pound excess capability would permit carrying sufficient life support and electrical power equipment and supplies for three men to remain on the Moon for possible as long as 30 days.

It appears, therefore, that if extended lunar exploration and lunar base operations are undertaken, more economical

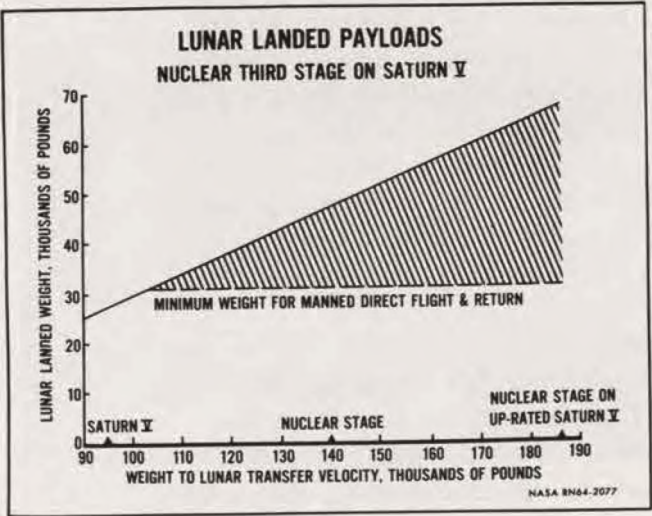


Fig. 68

operations, fewer launches and the ability to land on, and explore, all parts of the Moon could be provided by the use of a nuclear third stage on the Saturn V vehicle. This direct flight capability might be also provided by the chemical upgrading of the Saturn V. However, a nuclear third stage could provide advantages over the chemically upgraded version when used for unmanned deep-space exploration.

Figure 69 shows the payload that can be achieved for several representative missions, where a high-energy upper stage is added to both the Saturn V and the Saturn V/Nuclear. The increase in payload that results from the use of the nuclear stage is represented by the dashed portion of the bars. As an example, it is interesting to point out that the Mars orbit payload could be increased from approximately 30,000 to 50,000 pounds by use of a nuclear third stage. The figure shows the wide range of missions, including extra-ecliptic, solar probe, and other planetary missions, for which the nuclear-powered stage provides large increases in the payload capability of Saturn V. Such performance margins would be useful in our future space activities in providing increased mission flexibility and capability.



Fig. 69

Studies of propulsion for long-range missions indicate that nuclear electric propulsion with its very high specific impulse may offer some advantages over nuclear rocket and chemical propulsion--especially for very long distance unmanned missions to Jupiter, Saturn, or beyond.

Practical use of electric propulsion will require very high-capacity nuclear power sources capable of dependably producing several megawatts of electrical energy for period of 10, 20 or 30 thousand hours. The advantages of electric propulsion over nuclear rocket propulsion will depend heavily upon the power source specific weight (normally expressed in pounds per kilowatt). Estimates are that reactor power supplies currently under development will weigh about 30 to 40 pounds per kilowatt; with weights of 30 pounds per kilowatt or less, electrical propulsion will be competitive with other advanced types of propulsion.

Much of the payload weight which might be delivered by electrical propulsion will necessarily consist of the weight of the nuclear reactor electrical power source. However, one of the major needs of future space exploration is for high-capacity sources of electrical power. The nuclear power source would therefore serve a dual role in that it would also be available for purposes such as operation of communications, instruments, and life support systems as well as for propulsion.

Development of light-weight, megawatt-level, nuclear electric power sources having high reliability for thousands of hours of continuous operation is a long-term undertaking. However, technological development experience has repeatedly shown that with reasonably-paced

research efforts, solutions to seemingly insurmountable technological problems often turn out to be straightforward and practical.

Advanced technological developments, such as the propulsion work just described, are essential if this country is to maintain a logical continuity of effort and to retain flexibility in selecting its future missions and national space goals. For example, the nuclear rocket program was started in 1955 by the AEC and the Air Force. Now, 10 years later and after extensive technical effort, data have been obtained that experimentally verify the analytical predictions of performance for this type of propulsion. In looking ahead, important uses for these systems are now clearly seen. Considering the high costs and long lead times that will be involved in the development of operational advanced propulsion systems for future missions, such as nuclear rocket and nuclear electric systems, significant cost advantages over the long term can be assured if technical problems that may arise in engine and vehicle system development and operation are uncovered and solved as part of a technology effort. Experience has clearly demonstrated that encountering such problems for the first time in the course of urgent operational system development results in large cost overruns and slipped schedules. Decisions on missions should be made on the basis of technology that is in hand or close to being available.

If we are to undertake advanced space missions such as those described in this section, the technological basis -- including system engineering as needed -- must be established in the years before firm decisions are made. NASA's propulsion, vehicle, power, and other technological programs are all being directed in recognition of these points.

Technology

This section of the report is concerned with the research and technological advances which must be made to support the long-range missions. One point to be emphasized is that although the technological developments to be discussed are included under the "long-range" category, the research and technology development must be supported now and continued throughout the immediate future so that the needed technology will be available in time to undertake longer range missions of the type discussed here or others, not now foreseen, which may later become important. In a well-planned program, development of the needed technology should precede by several years a commitment to an advanced mission. The level of the technological development will determine to a large extent what missions can or cannot be undertaken at a given time.

In this section, the major technological advances needed in several areas for near-future and long-range future programs will be reviewed and some of the advances now being made, or needed, will be indicated.

Possibly the most clearly defined need for a major advance in technology is in the area of spacecraft electrical power sources. Plotted in Figure 70 are typical requirements for several missions. The current Mariner spacecraft

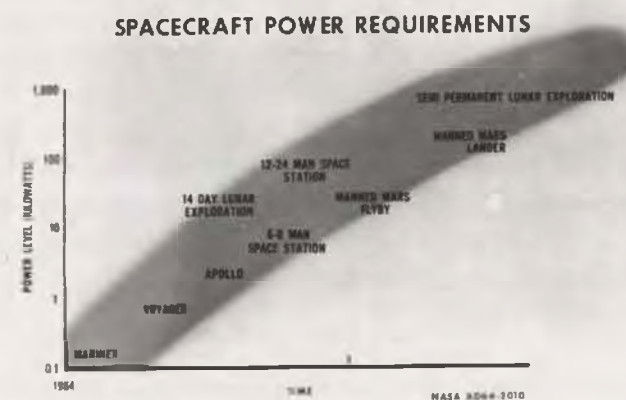


Fig. 70

will use on the order of a few hundred watts of power, which will be obtained from solar cells. Future unmanned planetary exploration spacecraft, such as Voyager, will require about one kilowatt, and six-to nine-man orbiting space laboratories will require many kilowatts. As more advanced missions (such as extended lunar expeditions, manned Mars fly-by missions, or large manned space stations) are undertaken, power requirements will approach 50 to 100 kilowatts. In the more distant future, missions such as the establishment of a lunar base or a manned planetary landing will require powers in excess of 100 kilowatts. Power needed for electrical propulsion would be on the order of several megawatts, which is completely outside the scale of this figure.

Spacecraft power requirements on the order of a few hundred watts or less have been met, and may continue to be met, by solar cell arrays, except for those spacecraft which operate too close to, or too far from, the Sun. Also, as larger power requirements arise, solar cells are less useful because of the very large surface areas and structural weights involved.

Fuel cells (such as those planned for use in the Apollo spacecraft) will be useful for delivering several kilowatts of power for periods of up to perhaps 1,000 hours, but require cryogenically-stored supplies of liquid hydrogen and liquid oxygen. (On the other hand, the hydrogen-oxygen reaction produces water which is useful in manned vehicles.) Continuing research and development on fuel cells will be primarily aimed at reducing the weight of the cells, at increasing the electrical energy produced for a given quantity of hydrogen and oxygen, at increasing their operating life times, and at developing dependable re-start characteristics.

Radioisotope sources have a great potential range of application from the point of view of weight, size, and life-time; our studies have shown that many future missions depend upon the development of isotope power sources in the 500 to 1,500 watts power range.

However, in addition to the basic developmental problems normally associated with any new device, radioisotope power supply development involves two additional difficult problems: one is the radiation shielding problem, especially if beta emitters are used, and the other is that the National production rate of preferred isotopes, such as plutonium 238 or polonium 210, may be inadequate for use-rates greater than a few power supplies per year. Additional National facilities maybe required to produce an adequate supply of these isotopes.

Nuclear reactor power plants will be needed for missions such as extended lunar base operations, manned interplanetary flights, or electric propulsion. Preliminary design efforts include the SNAP-8 system (35 kilowatts) and higher-power systems such as the SNAP-50 (300 kilowatts) system. Shielding weights are a significant problem in the use of these systems--especially where use in manned vehicles is contemplated. For lunar base operation, reactors may be buried in the lunar soil to provide the necessary shielding.

Another area where definite technological advances must be made for future long-distance missions is that of spacecraft-to-Earth communications. Available communications technology has, in general, been adequate for transmitting to Earth scientific measurements made by current spacecraft, with the major exception being Mariner IV.

As a result of past efforts in the development of large parabolic receiving antennas and sensitive electronic systems of the Deep Space Instrumentation Network, it was possible on Ranger VII to transmit, within about 15 minutes, more than 4,000 good quality television pictures over the

250,000 miles from the Moon to the Earth. However, at planetary distances of tens or hundreds of millions of miles, the information transmitting capacity of the communications link decreases drastically. If all other factors remain constant, the capacity of a radio communications link decreases as the square of the transmission distance. This means that the Mars-to-Earth data transmission capacity of present facilities is on the order of 1/1,000,000 of their Moon-to-Earth capacity. If the Ranger VII spacecraft had been flown to Mars, only a small fragment of one picture could have been transmitted to the Earth in the time interval of approach. The Mars Mariner launched last November will transmit about one TV picture every 10 hours, using an actual transmission time of 8 1/2 hours for each picture.

Figure 71 shows the data transmission capacity, in bits per second, for the maximum Mars-Earth distance of 250,000,000 miles. The lower shaded horizontal bar shows that on the order of 10 to 100 bits per second are required to transmit about one TV picture per day. Voyager spacecraft will require at least a few thousand bits per second.

The middle horizontal shaded bar at 10^5 bits per second shows the data transmission requirement for a typical manned planetary spacecraft. The upper horizontal shaded bar between 10^6 and 10^7 bits per second indicates the capacity needed if a large number of television pictures, similar to Ranger VII photos, are to be transmitted over the Mars-to-Earth distance.

Past improvements and present capabilities are indicated by the solid line, which shows a current capability for transmission of approximately one television picture in 8 1/2 hours. Also shown are some of the technological advances which might be undertaken to meet future communication requirements. These include increasing the spacecraft transmitted power to 100 watts, increasing the size of the spacecraft antenna diameter from 4 to 12 feet, and use of 210-foot-diameter antennas on the ground.

Requirements beyond about 10^4 bits per second are beyond the capabilities of techniques and facilities anticipated within the next several years. Some of the needed additional capacity may be derived from the use of still larger antennas on the spacecraft and even higher-powered spacecraft transmitters. These, of course, require still larger electrical power sources aboard the spacecraft. Beyond this, further improvements might come from the use of larger receiving antenna areas on the ground. Larger single-dish antennas do not appear practical but the needed larger areas might be realized by arraying a number of 100 - to 200 - foot antennas whose outputs would be combined to provide the equivalent of 500-to 1,000-foot diameter antennas.

Beyond about 10^5 bits per second, further increases in communications link capacity might come from the use of lasers and light frequencies for data transmissions. There are, however,

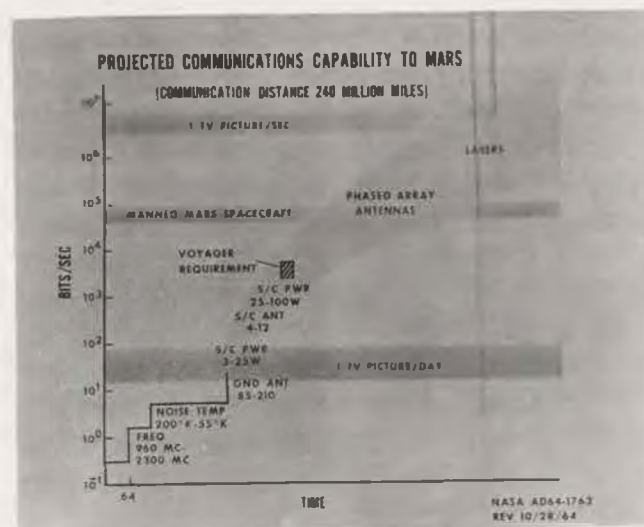


Fig. 71

many problems associated with laser communication systems whose solutions are as yet not clearly foreseen. For example, light beams do not penetrate clouds or fog, the power output of current lasers is low, and modulation and de-modulation techniques are as yet crude. In addition, the basic advantages of light frequencies over radio frequencies for communications are derived from the concentration of transmitted light energy within an extremely narrow beam; to use this beam requires that it be pointed with extremely high precision at the exact spot where reception is desired.

Figure 72 illustrates the increase in precision with which spacecraft instruments must be aimed or pointed. The required angular precision, in degrees, is shown for several space missions. Current operational requirements can be met with pointing precision on the order of 1/10 to one degree. The Advanced Orbiting Solar Observatory (which, as previously discussed, will observe an area of the Sun's surface only 20 arc-seconds in diameter) will require a pointing accuracy on the order of 1/1000 degree. The Orbiting Astronomical Observatory requires an even higher precision, on the order of 1/10,000 degree.

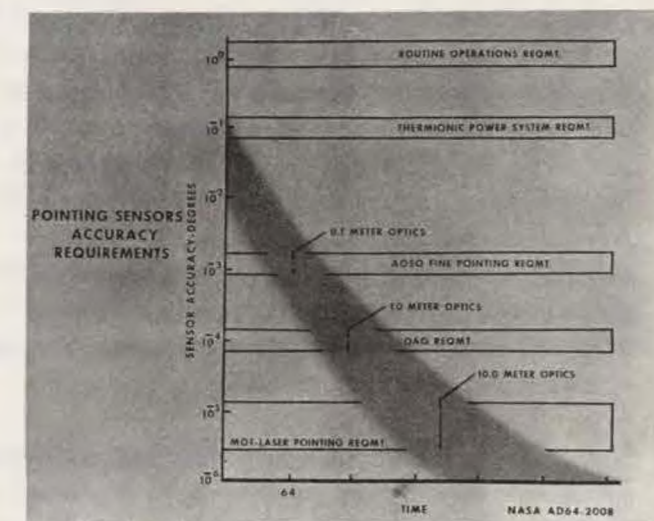


Fig. 72

Two types of pointing requirements are to be noted: the OAO, once it has located a particular star to be observed, can use the point of light provided by the star as a target to maintain its pointing precision; other requirements, such as for the AOSO, are more difficult to meet since instruments must be pre-programmed to point at a particular spot where no pinpoint "target" is available.

Systems such as a manned orbital telescope or a laser communications system require even higher pointing precisions, on the order of 1/100,000 of a degree. This serves to illustrate the interdependence of the technical requirements: the advantages of laser communications systems cannot be realized until the technology which provides for very precise pointing has been developed.

NASA's future efforts aimed at meeting some of these requirements will include research and development on inertial sensors which use gas or electrostatic bearings, or possibly superconducting magnetic suspension methods, as well as star trackers which automatically recognize and lock on various star patterns or constellations. Work is also being done on sensors which can recognize and lock on the horizon line of the Earth, Moon, or another planet in order to provide a reference for control of the vehicle's attitude.

Sterilization of planetary spacecraft, as necessary to prevent contaminating another planet represents another difficult technical problem. As indicated in Figure 73, a specification has been established that the probability of landing contaminating bacteria on Mars should be held to less than one chance in 10,000. To meet this requirement, planetary

vehicles must be sterilized even more thoroughly than is required by, or available from, the best hospital operating room techniques.

Thus far, the only known effective method of sterilization is the application of moist heat at 135° C for 24 hours. This generates serious reliability problems, since many components or materials such as batteries, plastics, pyrotechnics, scientific instruments and many electronic parts are either seriously damaged or completely disabled by high-temperature sterilization processes. Additional research is necessary, either to develop components which are unaffected by high temperatures, or to develop other effective sterilization methods which use lower temperatures and are less damaging to critical spacecraft components.

The sterilization requirement also sharply increases the difficulty of virtually all phases of the spacecraft fabrication, calibration, assembly and repair, since strict clean-room procedures--"untouched by human hands"-- must be used throughout.

Components such as batteries which cannot be made to withstand other sterilization procedures may have to be encased in impact-proof containers which will not break open even under the impact of hard landings on other planets.

All manned spaceflight missions require life-support systems to supply food, water, breathable and uncontaminated cabin atmosphere, and to dispose of waste materials. Figure 74 shows the advances which must be made in life support systems for longer-duration manned space missions of the future. The period of time during which the system must operate continuously without resupply, repair, or readjustment is shown for various types of manned space missions.

Earlier systems must support two or three men for 30 to 90 days; extended explorations of the lunar surface or large permanent manned space stations might be expected to operate for much longer periods -- 4 to 8 months-- without resupply; and manned expeditions to the planets must of course operate for full round-trip travel times of from one to 3 years.

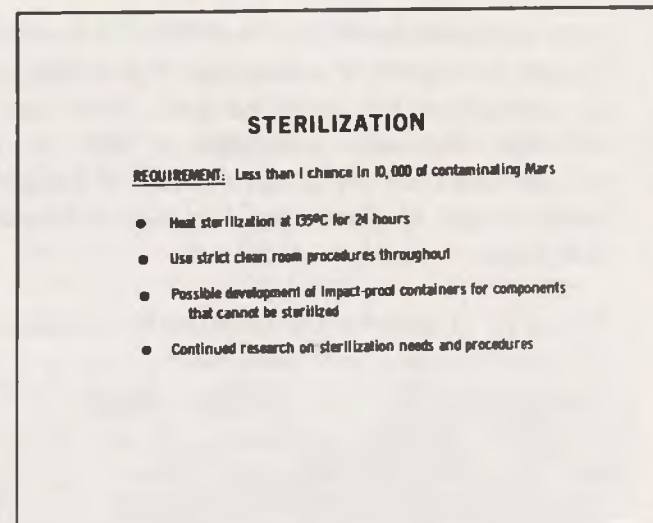


Fig. 73

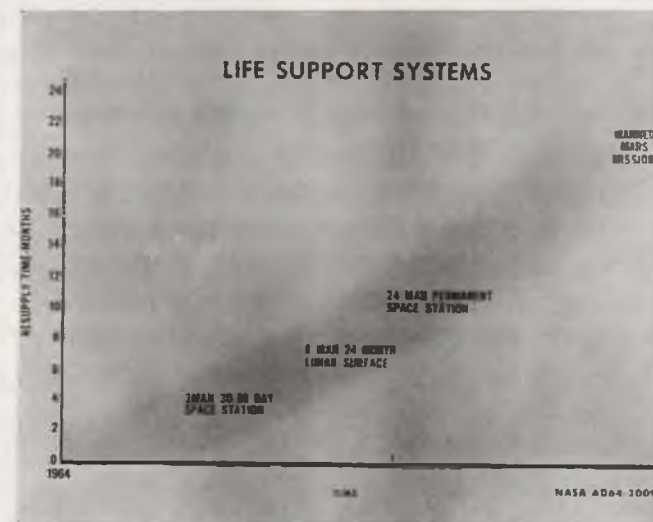


Fig. 74

For the shorter duration missions (up to 30 days), or for a near-Earth mission where resupply can be comparatively frequent, food, water, and oxygen can be carried along with the vehicle or delivered by additional supply vehicles launched from Earth. However, for longer missions of 60 days or more, it is not practical to carry along all needed supplies, so that life-support systems which provide for recovery and reuse of water and oxygen must be used.

The research and development work to be done here will include systems and techniques for reclaiming drinking water from wash water or waste products; techniques for recovering oxygen from expired carbon dioxide, and methods for detecting and removing dangerous contaminating gases from the cabin atmospheres. Development of dependable systems must also include extensive testing of these systems on the ground, using men living and working under closely simulated space ship conditions for long periods of time.

Considerable research effort will also be devoted to the study of man himself--his physiological and psychological problems. Future efforts will be aimed at obtaining a better understanding of man, and at determining his best utilization in advanced aerospace systems. The problems to be studied will include:

- a. The effects of weightlessness, including possible states of disorientation, decalcification of bones, and decreases in cardiovascular tone. Bone decalcification will be studied on Earth by means of prolonged bed rest and immobilization. The effects of weightlessness on the cardiovascular system cannot be studied on Earth but will require a prolonged zero-G environment available only in manned vehicles in space;
- b. Development of work-rest programs most effective for spacecraft crews. With the loss of diurnal rhythm while in space, unusual work-rest cycles may prove more efficient than those normally used on Earth;
- c. Possible physical problems such as a depth perception, space myopia, and high contrast effects;
- d. Effects of radiation--particularly of proton radiation ---on living tissues. These studies will be carried out using cyclotron experiments, supplemented by theoretical calculations, on tissue; and
- e. Parasite-host relationships existing in man. This subject has been given added emphasis by a recent five-man, 30-day chamber test which revealed that Staph Aureus dominated other micro-organisms in the body and eventually became the only bacteria present.

Improvement of space system reliability is another area which will require a continued, vigorous research and development effort. Many of the prospective future missions are of much longer duration than previous missions and will consequently require systems capable of operating for much longer periods of time without failure. For example, since even a one-way trip to the planet Mars requires about 7 months, an unmanned planetary spacecraft must operate successfully for at least this period of time to obtain even a minimum degree of success,

as compared to an Earth satellite which normally will obtain some useful data even if its useful lifetime is no more than a few days or a few weeks.

Future reliability requirements dictate that the failure-free operating lifetimes of many individual components and parts used in spacecraft systems must be improved by factors of 100 to 1,000. As outlined in Figure 75, future efforts aimed at realizing these levels of improvement will include study and research on the basic physics of the aging and deterioration of electronic parts and materials; continued effort to develop more reliable design, fabrication, and testing procedures; an increased emphasis on the use of redundancy and other techniques for ensuring long operating lives; and development of effective management procedures which ensure that effective reliability and quality control procedures are strictly followed at every stage of spacecraft design and fabrication.

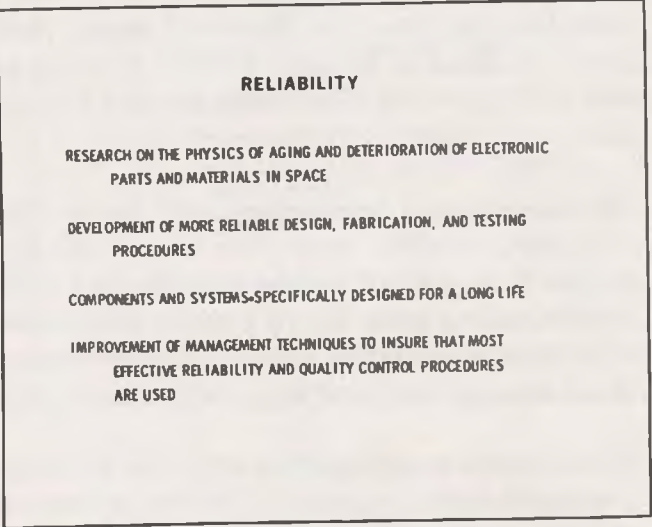


Fig. 75

VI SUMMARY

Our study of future programs has covered three major categories as illustrated earlier in Figures 4, 34, and 54, repeated here for ease of reference. These have covered:

- a. A review of the capabilities being developed by current programs;
- b. Intermediate missions which would support National objectives in space and afford steady progress toward longer-range goals, and at the same time make most effective use of capabilities developed thus far; and
- c. Long-range missions which may comprise the Nation's space exploration goals in the decades ahead.

In the areas of aeronautics, satellite applications, unmanned and manned space exploration, launch vehicles, and research and technology development, it is possible to trace horizontally the development path from 1958 to a decade or further into the future. It is obvious that there is increased uncertainty as the plans are projected into the future.

The details of these new missions, such as specific spacecraft designs and exact mission plans will, of course, be the subject of continued study by Headquarters and Field Centers of NASA, by interested government agencies, by universities, and by industry. Continued

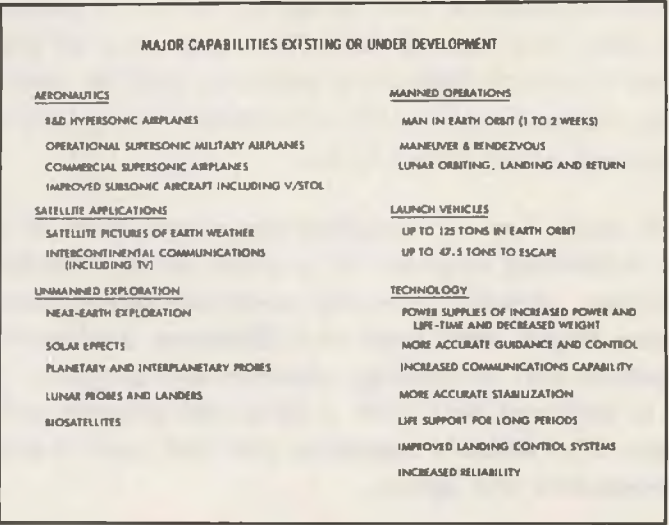


Fig. 4

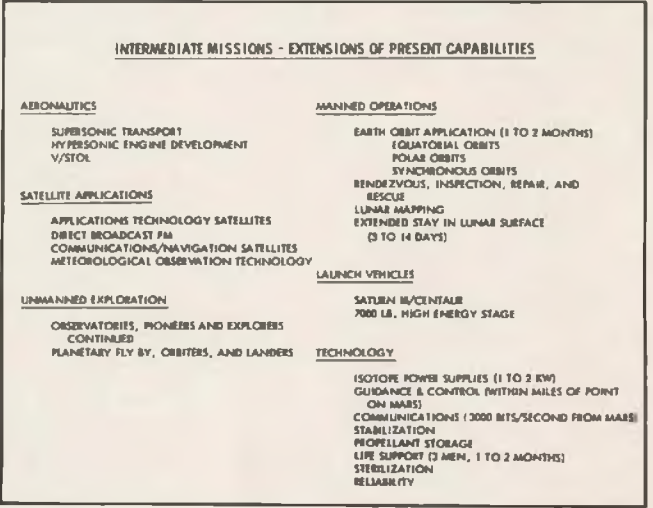


Fig. 34



Fig. 54

space exploration will be an evolutionary process in which the next step is based largely on what was learned from the experience of preceding research and flight missions. The pace at which these new programs will be carried out will necessarily depend upon many other factors, such as the allocation of budgetary and manpower resources and the changing National needs of the future.

This study has not revealed any single area of space development which appears to require an overriding emphasis or a crash effort. Rather, it appears that a continued balanced program, steadily pursuing continued advancement in aeronautics, space sciences, manned space flight, and lunar and planetary exploration, adequately supported by a broad basic research and technology development program, still represents the wisest course. Further, it is believed that such a balanced program will not impose unreasonably large demands upon the Nation's resources and that such a program will lead to a pre-eminent role in aeronautics and space.

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TO:
GEORGE REEDY

FROM:
MAC KILDUFF

EXECUTIVE

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THE FOLLOWING HAS BEEN SUBMITTED TO US BY JULIAN SCHEER FOR POSSIBLE USE BY THE PRESIDENT IN CONNECTION WITH QUESTIONS RELATING TO THE SOVIET SPACE SHOT.

BACKGROUND FOR THE PRESIDENT'S SATURDAY PRESS CONFERENCE

IN ORDER TO DEVELOP PREEMINENCE IN SPACE, THERE ARE MANY IMPORTANT MILESTONES WHICH MUST BE MET AND PASSED. AS BOTH THE SOVIET UNION AND THE UNITED STATES SEEK TO PUSH FORWARD THE FRONTIERS OF SPACE, FIRST ONE NATION AND THEN THE OTHER WILL ACCOMPLISH THESE GOALS.

WE ARE PROUD THAT THREE-FIFTHS OF THE NATIONS OF THE EARTH HAVE VOLUNTARILY JOINED WITH US IN THESE ENDEAVORS. OURS IS NOT A PROGRAM FOR NATIONAL PRESTIGE. OUR PURPOSE REMAINS FIRMLY FIXED ON THE OBJECTIVE OF PEACE. THE FRONTIER OF SPACE IS ONE THAT WE BELIEVE ALL MANKIND CAN AND SHOULD EXPLORE TOGETHER FOR PEACEFUL PURPOSES.

THE PRACTICAL BENEFITS OF SPACE HAVE ALREADY BEEN DEMONSTRATED DRAMATICALLY BY A SERIES OF FIRSTS IN OUR PROGRAM. WE CAN MAP THE GATHERING STORMS, WE GUIDE SHIPS THROUGH THE SEAS, AND WE CAN COMMUNICATE WITH THE WORLD.

IN THE LARGE SATURN I VEHICLE, WE HAVE DEVELOPED THE MOST POWERFUL BOOSTER IN THE WORLD. WE HAVE GONE TO VENUS, THE MARINER IV SPACECRAFT IS ON ITS WAY TO MARS, AND TWO RANGER SPACECRAFT HAVE GIVEN THE WORLD'S SCIENTIFIC COMMUNITY MORE THAN 11,000 CLOSEUP PICTURES OF THE MOON'S SURFACE.

THE RUSSIANS ARE TO BE COMMENDED FOR PASSING ONE OF THE MILESTONES WHEN A COSMONAUT LEFT HIS SPACECRAFT AND VENTURED FORTH INTO THE VACUUM OF SPACE, AN EXPERIMENT WE PLAN ON A FUTURE FLIGHT. THERE ARE OTHER FEATS WHICH WILL BE MET BY BOTH OUR PROGRAMS. WE WILL LEARN ABOUT MAN'S ABILITY TO SPEND LONG PERIODS OF TIME IN SPACE; WE WILL RENDEZVOUS AND DOCK SPACECRAFT; AND WE WILL MANEUVER A SPACECRAFT IN SPACE.

WE MOVED FROM THE SUCCESSFUL MERCURY FLIGHTS WITH ONE MAN IN A SMALL SPACECRAFT TO THE GEMINI PROGRAM. AFTER TWO SUCCESSFUL UNMANNED FLIGHTS, WE WILL FLY TWO MEN FOR THE FIRST TIME ON TUESDAY. THERE WILL BE NINE OTHER FLIGHTS IN WHICH WE WILL ATTEMPT TO PASS MORE SPACE MILESTONES.

FOLLOWING GEMINI, WE WILL MOVE IN ORDERLY FASHION TO THE APOLLO PROGRAM TO LAND A MAN ON THE MOON IN THIS DECADE.

WITH THE FULL SUPPORT OF THE PEOPLE AND THE CONGRESS THIS YEAR, "SUBSTANTIAL STRIDES HAVE BEEN MADE IN A VERY BRIEF PERIOD OF TIME-- AND THERE ARE MORE TO COME. WE EXPECT TO EXPLORE THE MOON, NOT JUST VISIT AND PHOTOGRAPH IT. WE PLAN TO EXPLORE AND CHART THE PLANETS AS WELL. WE SHALL EXPAND OUR EARTH LABORATORIES INTO SPACE LABORATORIES AND EXTEND OUR NATIONAL STRENGTH INTO THE SPACE DIMENSION."

I HAVE SAID MANY TIMES THAT THE PURPOSE OF THE AMERICAN PEOPLE REMAINS UNCHANGED AND UNWEAVING. WE ARE DETERMINED THAT SPACE SHALL BE AN AVENUE TOWARD PEACE.

!END

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3/27/65
Date

NAME

Webb, James E.

ORGANIZATION

NASA

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FINAL ACTION

Memor for President pm
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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

March 26, 1965

EXECUTIVE SECRETARY

MEMORANDUM TO THE PRESIDENT

Subject: Space Activities

1. Congress

- a. A subcommittee of the House Science and Astronautics Committee has voted to reinstate \$6.2 million to finance the 260 inch solid fuel rocket program and \$15 million for the M-1 liquid fueled engine. Similar treatment by the subcommittee is also expected for the Snap-8 nuclear power unit.
- b. The House Armed Service Committee has voted to cut over \$650 million from DOD's Research, Development, Test and Evaluation budget request. The committee was reported as being critical of the handling of the MOL program.
- c. A subcommittee of the House Science and Astronautics Committee is reported as having voted a \$103 million cut in funds for the Apollo manned lunar landing program.
- d. The House Government Operations Information Subcommittee released a report critical of NASA for not releasing information on the tracking of Soviet space flights.

2. Launches

- a. Ranger IX, launched March 21, successfully landed in the lunar crater Alphonsus March 24. Live television pictures of its descent were shown to the nation. Some of the about 6000 pictures indicated that volcanic activity may have occurred on the moon.
- b. On March 23, the first manned Gemini was launched. It was successfully steered by Astronauts Grissom and Young through three changes of orbit, for a world's first in manned space flight.
- c. The Soviet Union launched Cosmos 64, March 25, into a low circular orbit inclining from the equator by 65 degrees.
- d. The U. S. placed a military payload in near polar orbit March 25, using a Thor-Agena vehicle.

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e. The third launching of the Blue Streak, first stage of the ELDO Europa I vehicle, took place successfully on March 22 from Woomera, Australia.

3. Pending Launches

a. SNAP 10A is scheduled for launch on April 1. It will be the first nuclear reactor flown in space. Part of the 500 watts of power to be produced by the reactor will be used to drive an ion engine.

b. Launch of the Communication Satellite Corporation's "Early Bird" communications satellite is scheduled for April 6.

4. Aeronautics. The RS-70 aircraft broke the world aviation weight and supersonic endurance records March 24 with a take-off weight of a half-million pounds and sustained supersonic flight for 80 minutes.

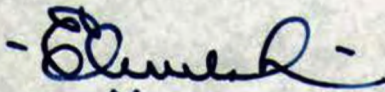
5. Applications Satellites

a. Tiros satellites were used to obtain weather data for the Gemini flight. Coverage of Africa, the Indian Ocean, and Pacific provided information available from no other source. Also, Syncom assisted in the communications network.

b. A South Pacific tropical storm was sighted by Tiros IX, March 19, and warnings were sent to Guam, Fiji, Australia, and New Zealand.

6. Navigation Satellites. The Navy has provided shipboard navigation satellite receivers to two private oceanographic ships. Sets are being provided to NASA for testing of other civilian applications.

7.	<u>Space Payload Success Box Score</u>			
	(March 26)			
	USA		USSR'	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth Orbital	14	24	4	14
Escape	1	2	0	0



E. C. Welsh

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The White House
Washington

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EXECUTIVE

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THE WHITE HOUSE
WASHINGTON

March 24, 1965

MEMORANDUM

FOR: JACK VALENTI

George has asked me to send the attached proposed press release to you for clearance by the President. The President has expressed an interest in the past in approving any press release having to do with atomic energy.

Mac

Mac Kilduff

Attachment

Geo. Talk With Pres.
NEED - IN SPACE
MIGHT FRI GETTER PEOPLE

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MAR 27 1965
CENTRAL FILES

DRAFT - 3/23/65

The President has authorized the launch of a compact nuclear reactor power system (SNAP 10A) into space. Such event is anticipated in the near future. The launch of this AEC project will be made from Vandenberg Air Force Base on an Atlas Agena rocket.

The successful launch of SNAP 10A will represent an historic milestone in our nation's space and atomic energy programs. The system is designed to produce about 500 watts of electricity by thermoelectric conversion of heat from the nuclear reactor. Part of the electricity produced will be used to test an ion propulsion engine developed by the Air Force.

This is another example of our growing confidence and our special interest in using nuclear energy for peaceful and constructive purposes. The exploration and travel in outer space present most challenging opportunities for such use. The test of our first space reactor will be an important step in the development of the type of power needed to insure constructive growth in our space program.



(28)

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE

OS
FG 11-4

March 12, 1965

EXECUTIVE SECRETARY

MEMORANDUM TO THE PRESIDENT

Subject: Space Activities

1. Congress

a. Senate Committee on Aeronautical and Space Sciences continues to hear witnesses on NASA's FY 1966 authorization. A DOD hearing on space is also scheduled for March 15.

b. Subcommittees of the House Science and Astronautics Committee plan to end hearings on NASA's FY 1966 authorization, March 26.

2. Launchings

a. A new record in the number of satellites launched by a single vehicle was set March 9 when a Thor Agena launched by the DOD from Vandenberg placed eight instrumented payloads in near polar orbit.

b. A Thor Able Star vehicle launched from Vandenberg by the Department of Defense March 11 placed two satellites into polar orbits.

c. The Soviet Union March 7 placed Cosmos 59 into low earth orbit inclining 65 degrees from the equator. The heavy weight and orbit indicate that an attempt may be made to recover the satellite within a few days.

3. Weather Satellites. Tiros IX made 15 separate sightings of tropical storms in the South Pacific and Indian Ocean during the past week and warnings were sent to 12 countries.

4. Pending Launches

a. Preparations are proceeding for the launch of the Gemini spacecraft with Grissom and Young aboard. It is scheduled for about March 22.

b. The last Ranger (lunar picture-taking spacecraft) is now scheduled for launch during the period of March 19-25, and the lunar aim point of this mission will be determined this week.

c. Launch of the ComSat Corporation's "Early Bird" (synchronous satellite), scheduled for this month, has been delayed for the replacement of some electrical components.

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5. Mars Probes

a. Mariner IV (Mars picture-taking spacecraft) is in radio-readiness for the remaining 124 days of its flight to Mars. The satellite is now over 30 million miles from earth.

b. It has been reliably reported that radio communication is continuing with the Zond II spacecraft. It is indicated that it will pass within 900 miles of Mars. (Mariner IV is scheduled to pass Mars at about 5400 miles.)

6. Firefly. NASA is developing an instrument that turns chemical energy to light by an enzyme system similar to that of the firefly insect. The instrument will detect life in space and will be used to study the contamination problem on sterilized probes going through the earth's atmosphere.

7. Launch vehicles. A NASA-DOD study concludes that combinations of booster stages, now under development or operational, are capable of performing planned space program launches during the next five to seven years.

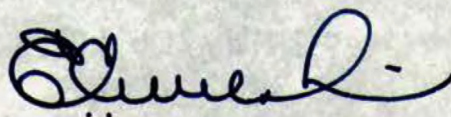
8. French Cooperation. The French Government has agreed to consider, on a case by case basis, the U. S. request to station search and rescue aircraft at Papeete, Tahiti during the Gemini flights.

9. Syncom II. This synchronous communications satellite has been moved to a new position over the Indian Ocean. The purpose is to obtain improved service for DOD with the East.

10. ComSat Consortium. The number of nations now in the international commercial communications satellite consortium has grown to 45.

11. Space Payload Success Box Score
(March 12, 1965)

	USA		USSR	
	1964	1965	1964	1965
Earth Orbit	14	20	3	9
Escape	1	1	0	0



E. C. Welsh

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The White House
Washington



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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON

EXECUTIVE

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FG11-4

EXECUTIVE SECRETARY

March 19, 1965

MEMORANDUM TO THE PRESIDENT

Subject: Space Activities

1. Congress. The Senate Aeronautical and Space Sciences Committee heard DOD witnesses on the military aspects of the national space program in executive session March 15. NASA witnesses will be called back to testify on details of the current authorization during the week of March 22.

2. Launches.

a. The Soviet Union launched a manned Voskhod II March 18 and recovered it March 19 after 17 orbits. One of the two cosmonauts emerged from the spacecraft and moved about at the end of a tether line. TV pictures of this maneuver were relayed over the Soviet network. This was an extravehicular "first" in space.

b. The Department of Defense launched a satellite into near polar orbit March 18 with a Thor Altair launch vehicle from Vandenberg.

c. The Soviet Union launched three satellites (Cosmos 61-63) using a single launch vehicle March 15. The satellites, launched into an orbit inclining 56 degrees from the equator, appeared to be a duplicate of launches made in August 1964 and February 1965.

d. The Department of Defense placed a satellite into polar orbit March 12, using an Atlas Agena launch vehicle.

e. The Soviet Union launched Cosmos 60 into a low orbit with an angle of inclination from the equator of 65 degrees March 12.

f. So far this year, the Soviet Union has launched more than three times as many satellites into orbit as they had at this time last year.

3. Pending Launches. The third Ranger satellite programmed to take pictures of the moon is now scheduled for launch March 21. The Gemini space capsule which is scheduled to orbit two astronauts three times around the earth is scheduled for launch March 23.

4. OAQ. The instrument packages scheduled to be placed in the first Orbiting Astronomical Observatory have been revised so that the launch date scheduled for late this year will be met. The satellite will carry three X-ray telescopes, and a photometer telescope to measure the energy of the stars.

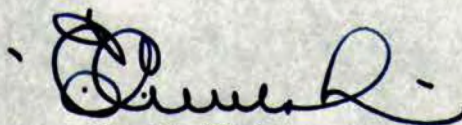
5. Aeronautics. The Federal Aviation Administration has certified a new automatic approach and landing system to be used with the Boeing 720 B commercial liner. The limited approval covers only landings made under visual conditions with a pilot monitoring the system.

6. Syncom. The Syncom III satellite, now providing a valuable military communications link between Viet Nam and the U. S. is being maintained in a "stationary" orbit varying in diameter less than 650 feet out of 52,400 miles.

7. Soviet Astronauts. The Soviet Union has announced a program designed to allow Soviet astronauts to make welding repairs during manned space flights.

8. Space Payload Success Box Score
(March 19)

	USA		USSR	
	<u>1964</u>	<u>1965</u>	<u>1964</u>	<u>1965</u>
Earth Orbit	15	21	4	13
Escape	1	1	0	0


E. C. Welsh

MEMORANDUM

THE WHITE HOUSE
WASHINGTON

March 9, 1965

MEMORANDUM FOR

Mr. Valenti

I hope you remember that you had planned to send me Jim Webb's covering letter on the NASA planning document, as well as your summary for the President. I have not received them yet.

It would be helpful if we could have them right away since our Space Science Panel, a very knowledgeable group, is meeting today and tomorrow, and I would like to make the best possible use of them.

Don

Donald F. Hornig
Special Assistant for
Science and Technology

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EXECUTIVE
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*Mr. Valenti.
I sent this out
about 9:30 this
morning. Dr. Hornig's
office told me
to tell you.*

*Completed
EX-OS 2/17/65*

BRUGHT FORWARD

EXECUTIVE

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NAME

Webb, James

ORGANIZATION

NASA

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3/27/65

FINAL ACTION

President's Memo
to James Webb - re Report (NASA's)
of Future Programs Task Group

EXECUTIVE

RADIO CORPORATION OF AMERICA
R C A BUILDING
30 ROCKEFELLER PLAZA
NEW YORK 20, N. Y.



MF 3/A*

OS

March 3, 1965

The President
The White House
Washington, D. C.

My dear Mr. President:

Again, I have reason to be grateful for your generous thoughts of me.

Your message to the [★]American Legion, with its generous comments on my receipt of the National Commander's Award in Washington this past Monday, was deeply appreciated. I will make every effort to justify your evaluation through continued service to our beloved country.

I am taking the liberty, Mr. President, of enclosing the text of the address that I delivered on this occasion. It contains a strong plea for public support of the national space program, and I hope that it will help to stimulate a greater awareness of the vital nature of your administration's objectives in leading mankind's exploration of the cosmos.

With warm personal regards,

Sincerely,

EXECUTIVE

JV/1965/FG 216

February 27, 1965

OS

MEMORANDUM FOR ROGER STEVENS:

As the calendar looks now, I don't think the President is going to be able to attend the March 13 opening at the National Gallery of the exhibition of artistic works recording the epochal events of the Space Program.

The thing for us to do is to leave the situation fluid so the President could do this at the last minute if the schedule opens up.

JV
Jack Valenti

JV:hcb

Memorandum for Liz Carpenter from Jack Valenti with response at bottom, with enclosed memorandum for the President from Roger L. Stevens.

EXECUTIVE

OS

FG 411/military
operation

June 10, 1965

CONGRESSIO

Dear Congressman:

Thank you for sending to the President a copy
of your Subcommittee's report, "Government
Operations in Space."

Your courtesy is very much appreciated and the
findings and recommendations contained in the
report will be carefully studied.

Sincerely yours,

Lawrence F. O'Brien
Special Assistant
to the President

X
Honorable Chet Hollifield
House of Representatives
Washington, D. C.

jl/az

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CAPITOL S-5147

EIGHTY-NINTH CONGRESS
Congress of the United States
House of Representatives

MILITARY OPERATIONS SUBCOMMITTEE
OF THE
COMMITTEE ON GOVERNMENT OPERATIONS
RAYBURN HOUSE OFFICE BUILDING, ROOM B373
WASHINGTON, D.C. 20515

JUN 10 1965

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June 8, 1965

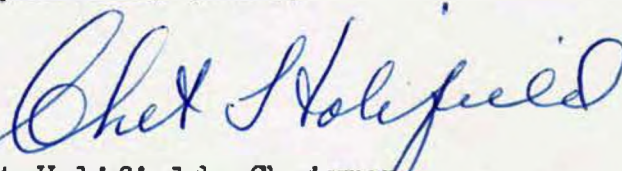
The Honorable
The President of the United States
The White House
Washington, D. C.

Dear Mr. President:

Enclosed is an official print of our report
on Government Operations in Space.

The first section is a summary analysis with
recommendations.

Respectfully yours,



Chet Holifield, Chairman
Military Operations Subcommittee

Incl.

THE WHITE HOUSE
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GOVERNMENT OPERATIONS IN SPACE

(Analysis of Civil-Military Roles and Relationships)

THIRTEENTH REPORT

BY THE

COMMITTEE ON GOVERNMENT
OPERATIONS



JUNE 4, 1965.—Committed to the Committee of the Whole House on
the State of the Union and ordered to be printed

U.S. GOVERNMENT PRINTING OFFICE

WASHINGTON : 1965

49-739

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LETTER OF TRANSMITTAL

HOUSE OF REPRESENTATIVES,
 Washington, D.C., June 4, 1965.

Hon. JOHN W. McCORMACK,
Speaker of the House of Representatives,
 Washington, D.C.

DEAR MR. SPEAKER: By direction of the Committee on Government Operations, I submit herewith the committee's thirteenth report to the 89th Congress. The committee's report is based on a study made by its Military Operations Subcommittee.

WILLIAM L. DAWSON, *Chairman.*

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Union Calendar No. 204

89TH CONGRESS } HOUSE OF REPRESENTATIVES } REPORT
1st Session } { No. 445

GOVERNMENT OPERATIONS IN SPACE

(Analysis of Civil-Military Roles and Relationships)

June 4, 1965.—Committed to the Committee of the Whole House on the State
of the Union and ordered to be printed

Mr. DAWSON, from the Committee on Government Operations,
submitted the following

THIRTEENTH REPORT

BASED ON A STUDY BY THE MILITARY OPERATIONS
SUBCOMMITTEE

On June 2, 1965, the Committee on Government Operations had before it for consideration a report entitled "Government Operations in Space (Analysis of Civil-Military Roles and Relationships)." Upon motion made and seconded, the report was approved and adopted as the report of the full committee. The chairman was directed to transmit a copy to the Speaker of the House.

I. SUMMARY, ANALYSIS, AND RECOMMENDATIONS

Government operations in space present complex problems of agency roles and relationships. From time to time great concern is expressed in the Congress and elsewhere about the value and effectiveness of these operations. The complexities are due in large part to the inevitable division of civil and military space activities, and the concern is intensified by the heavy costs in money, resources, and technical talents associated with the national space effort.

SOME BASIC QUESTIONS

Critical commentary shows up in many levels of discourse. There is a continuing, though somewhat erratic, national debate on the whys

and wherefore of the national space effort, in which questions of the following kinds are raised:

Is it wise to devote so large a portion of our national resources and energies to putting a man on the moon when pressing economic and social needs go unfulfilled?

Are there derivative benefits, through industrial and military applications, and to what extent do these justify the heavy investment in the civilian space program?

Has the multi-billion-dollar lunar landing program distorted the civilian space organization and caused a wide departure from the scientific space missions charged to NASA?

Are we concentrating too much on civilian space and neglecting military space with future risk to the national security?

Why is it necessary to have two lines of governmental endeavor in space?

If civilian and military agencies both must be involved, how can overlap and duplication be eliminated or avoided?

THE LUNAR LANDING COMMITMENT

Several of these questions, we may note, already are mooted by time and circumstance. The Government's commitment to the manned lunar landing program is so firm and the investment so heavy that there is no turning back. This goal of our space effort was officially declared in May 1961 and is now 4 years old. Of the \$20 billion which NASA estimates as the cost of the lunar landing program, about half will have been appropriated through the next fiscal year for research, hardware, facilities, and real estate. Although debate over the lunar landing program will continue, by now it is largely academic.

Committed as heavily as we are to landing a man on the moon, hopefully by 1970, the Federal Government should make every effort to reach that goal. NASA deserves to be fully supported in its planning and funding to achieve it.

This is not a counsel for hasty and reckless spending. Improved management techniques, better coordination, and avoidance of unnecessary duplication continually must be sought. But nothing of enduring value is to be gained by heavy budget cuts and the stretching out of the lunar landing program to an indefinite future.

The lunar landing goal is a bold and imaginative concept—in keeping with America's historic embracement of new challenges and great enterprises. It reflects a decision based upon considered findings of eminent scientists and engineers consulting the Federal Government in 1961 that a lunar landing was feasible in this decade. Government leaders understood that it was a risky yet realizable means of besting the Soviet Union in competitive space exploration.

And yet we are certain that the 1961 decision, however well considered and justified in the exigencies of the race for space, could not have taken into account the full nature of its impact on the American economy and society. This single decision pronounced by President Kennedy and ratified by the Congress in authorizing and funding actions, placed a draft on national resources for a whole decade. Because the overriding objective was to beat the Russians, necessarily the project would rate the highest national priority. The Nation's elite in science and engineering and management would be

called to its banner. Thousands of working people would be in its employ. Vast acres of real estate would be acquired and great new facilities built. The yearly budget for civilian space exploration would top \$5 billion, and about two-thirds of NASA's outlays would be devoted to the lunar landing effort. While the dimensions of this effort could be vaguely foreseen in the original decision, the detailed practical consequences were to change the economic destinies of whole regions and industries, the personal careers and the livelihoods of hundreds of thousands of American citizens, and the style and course of government for years to come.

THE UNCERTAIN RATIONALE

The ups and downs of national sentiment about the lunar program and the critical assaults from different sectors of opinion are reflected in the uncertain rationale in official quarters. There is a noticeable inclination, for example, to dwell on the industrial applications and the consumer "fallout" benefits of space exploration and particularly of the lunar program. Government officials, also sensitive to allegations that military space needs are being neglected, emphasize the close coordination of military and civil agencies, the values to the military of the knowledge and experience gained in these efforts, and the fusion of aims of both military and civil space activities in the interests of peace and security.

Clarification of the official rhetoric is needed. This Nation is dedicated to the peaceful uses of space, but it is a matter of simple prudence and caution that the potential military uses be carefully explored and more fully known. Our military aim in space, as in other media, is always protective, not aggressive, nor directed toward destruction and world domination. Our military aim is peaceful in the sense that our Armed Forces seek to preserve peace and discourage aggression, and since space technology can contribute toward that end, it must be exploited for defense purposes.

The largest and most costly part of our Government effort to develop the technology of space is the responsibility of NASA, a civilian agency with a broad charter for space endeavors. In terms of national prestige, or the expansion of scientific knowledge, or laying the technical base for operational systems of practical value, mastery of the space environment is important if not critical. But these values of space exploration and development enhance our military posture and effectiveness only in derivative or incidental ways, or in the negative psychological sense that failure to match or surpass an adversary nation's space achievements will be taken as a sign of deficiencies in national power and military strength.

It is our belief that not much is to be gained at this stage by trying to "sell" the civilian space effort, particularly the lunar landing program, on the basis of its derivative benefits to the Defense Establishment, or for that matter to the domestic economy. Considering the multibillion-dollar costs, the contemporary fallout benefits are relatively few and far between. There have been some, and there will be more, useful applications for producers or consumers, and much valuable information will come to the military from the civilian space effort, but at best these are modest benefits for the huge outlays required. The original aim in decreeing the national effort for a

lunar landing within the decade was to beat the Russians, and this it must remain. There is little use in trying to persuade people generally that their economic welfare is best advanced by putting a man on the moon, or to persuade the military authorities that this is the best way to spend dollars to strengthen the national security.

And to those critics in the scientific community who continually complain that basic science is but a small part of that vast and costly project, we would rejoin, in the light of its original aim, that basic science is not the paramount consideration. There will be a great deal of scientific knowledge gained, but primarily it is a great engineering, hardware-building, and training effort, not a scientific investigation. Even so, the scientists should take comfort from the enterprise, since the benefits to science are considerable and far greater than would have been achieved in its absence. The lunar landing project has energized many scientific disciplines in its behalf and has caused funds to be made available to many centers of learning for supporting scientific investigations of space.

THE MILITARY QUESTION

The military question is a more serious one.¹ Apart from the derivative benefits that the military acquire from a civilian space effort, the question remains whether military needs in space are being neglected or bypassed or insufficiently fulfilled due to the heavy emphasis on civilian space exploration and particularly the lunar program. The answer to this question is difficult. In formulating an answer, one must keep certain considerations in mind.

The Nation is committed by law and public policy to a dual civil-military space effort. It is not practicable or timely now, if it ever was, to merge military and civil space interests in a single agency inside or outside the military domain. In an earlier report we noted that it was deemed wise and politic to create a civilian space agency as a continuing affirmation of our desire for scientific exploration of space as a contribution to world peace and international good will.¹ The United States chose as a matter of national policy not to hitch space exploration to the military machine, even though the military would play an important part in space ventures and in support of civilian experiments.

When the lunar landing mission was announced, it would not have been practicable to assign it to the Defense Department. Not only would the heavy money outlays have cut into other important programs of more direct military value, but military planning and scientific talents and human and material resources would have been diverted from essential programs in ballistic missiles and other crucial elements of military strength. A national space effort of the dimensions and intensity now mounted would not have been appropriate under military auspices.

And in a broader context, space exploration is a many-sided effort which involves close cooperation and working arrangements among sundry civil government agencies of national and international scope. A civilian space agency is more suited than a military one for conduct-

¹ H. Rept. 1121, 86th Cong., 1st sess., entitled "Organization and Management of Missile Programs," pp. 141-147.

ing many space experiments, not only in pursuit of a broad basic space mission, but as a joint participant with other Federal agencies or other nations.

Whether it be a cooperative experiment in sounding rockets or weather satellites or communication relays or some other technical enterprise of scientific interest and possible value to an international community, our Government requires instrumentalities to execute these missions without being subjected to security complications or propaganda charges. For a continuing demonstration of our desire for international cooperation in space, of our dedication to human progress and the advancement of science, NASA stands as a more appropriate national symbol and Government center than the Department of Defense.

Military necessities remain. But the very logic which puts NASA in the forefront of civilian national and international space activities decrees that the agency cannot serve, except in limited and derivative ways, as the space branch of the military. This would result inevitably in a confusion of aims and objectives, would prejudice requirements of both sides, and would create only an illusion of security. The general public, which takes pride in our space achievements and supports these costly endeavors, somehow believes that beating the Russians to the moon or otherwise matching or excelling Soviet space performance, is intimately bound up with this Nation's defense and security. It is the solemn obligation of our policymakers in Government to insure that the space race truly does not ignore the military necessities, and to obtain this insurance by properly sorting out the issues and supporting the necessary programs.

THE DIVISION OF EFFORT

Whether in any given situation a space project is to be undertaken by NASA or the Defense Department cannot be decided readily on jurisdictional or doctrinal grounds. The reason lies partly in the exigencies of program planning and budgeting, partly in the nature of the technology. Space sciences and technology cannot be compartmentalized into military or civil, nor is it practicable to separate basic from applied research (or development) on an agency basis when agency missions or projects require the exercise of the whole range of scientific, technical, engineering, and construction activities. Framers of the National Aeronautics and Space Act of 1958 had to come to grips with this question, and the answer they gave was fashioned in pragmatic terms, as we show in section III. Space exploration would be a two-sided, military-civil effort and each side would be permitted to engage in those activities necessary to execute its missions.

Overlapping and duplication were anticipated and inevitable, and coordinating mechanisms were devised with the aim of minimizing or avoiding unnecessary duplication. Judgment will differ as to the efficacy of the coordinating mechanisms, the extent of cooperation, and the degree to which needless duplication has been avoided. In some areas cooperation has been good, in others noticeably absent or reluctant and induced mainly by congressional persuasion. The problem has many facets and is a continuing one. Understandably, agencies charged with large and important national tasks seek self-

sufficiency in resource control and management to insure successful performance. A considerable amount of duplication is unavoidable since the resources and facilities of one agency cannot be readily put at the disposal of another due to differences in geographic location and timing of separate agency tasks. In other cases, duplication in fact or in prospect is avoidable, and due care should be taken in program formulation, budgeting and program management to minimize needless duplication.

COORDINATING ARRANGEMENTS

The committee takes note of the numerous agreements for cooperation between NASA and DOD made at different times, for varying purposes, by many entities from headquarters on down. The subcommittee staff has tracked down almost 90 agreements which have been reduced to written form. These are listed in appendix D.

Such agreements plus many informal working arrangements are important and necessary because of similar or interacting technologies, resources, and operations in both agencies. Baffling in their sheer numbers and diversity, it is difficult to evaluate the effectiveness of these agreements or to determine significant gaps or omissions. The committee is convinced, however, that the many points of interaction between NASA and DOD offer unending opportunities for avoiding overlap or duplication, for conserving resources, and for effecting economies.

One of the big problem areas in interagency coordination is program support, which is demanding an ever-increasing share of the space budget. The committee does not believe that every time a new program is developed, whether in NASA or DOD, it is necessary to build new and separate or unique field and support facilities. If an existing control center or tracking network or supply warehouse can be utilized or adapted for new individual or mutual requirements, every effort should be made to do this. Where one agency has the bigger investment in facilities and resources or is the dominant user, arrangements should be worked out for single management to avoid or minimize duplication of facilities, supplies, and services. Standardization and single management, wherever appropriate, should be the order of the day.

Achieving greater efficiency and economy demands, among other things, that both agencies get together at the earliest stages of new program conception and planning, before hardware configurations become fixed and changes difficult. Also, reimbursement plans and procedures in cross-servicing need reexamination. A comprehensive agreement on reimbursement between NASA and DOD was signed in 1959 but has not been reviewed or revised since that time. The reimbursement process seems to be haphazard; at least it is not too well understood.

Top-level agreement, of course, is essential. Unless the agency heads give serious attention to such matters and demonstrate their willingness to cooperate, the coordination cannot be successful. The Aeronautics and Astronautics Coordinating Board, headed by the Associate Administrator of NASA and the Director of Defense Research and Engineering, with numerous panels and subpanels for designated technical areas, has become the working instrument for

coordination between the two agencies. The Board has examined many facets of mutual requirements and interagency relationships and has done useful work. However, it has no built-in, decision-making power. The persons who serve on the Board and panels are busy with other responsibilities, and usually they cannot get into all the "sticky details" of an issue. If the Board members or the heads of the agencies they represent disagree, the agencies go their separate ways and problems remain unresolved or are removed to another and higher forum.

Congress contemplated, in enacting the 1958 Space Act, that the National Aeronautics and Space Council would serve as the top-level coordinating mechanism in the President's behalf. The Council has done useful work from time to time, but it should be enabled and encouraged to assert itself more positively, to guide the agencies along paths of coordination and cooperation, seeking optimum use of space resources from a truly national standpoint. With the Vice President now serving by law as Chairman, and with challenging new space developments in prospect, the Council has an excellent opportunity to reestablish itself as a dynamic agency and as the leadership instrument for an integrated national space effort.

DEFENSE DEPARTMENT AT A DISADVANTAGE

Viewing NASA and DOD as competitive claimants upon the national treasury for funds and upon the public fancy for spectaculars in space exploration, it is obvious that Defense is disadvantaged. NASA is a large new agency with an exciting mission, widely publicized experiments, and generous funds to attract top talent for in-house employment and leading industrial organizations for engineering and hardware development. The NASA Administrator, with space as his main preoccupation, is in charge of an independent agency reporting directly to the President. The largest part of the agency's resources and energies in this decade can be devoted to a single finite goal or project—landing a man on the moon. Its program justifications to the Congress are examined and supported by House and Senate committees especially created to oversee the agency's mission. The President and Vice President of the United States are committed by statute and personal concern, and the obvious international prestige implications of the space effort, to close and continuing involvement.

In the Department of Defense, on the other hand, the military space effort now is largely concentrated in the Department of the Air Force and executed by the Air Force Systems Command. The commanding officer must go through a chain of command within the Air Force to the Secretary of the Air Force, and thence to the Office of the Director of Defense Research and Engineering, and finally to the Secretary of Defense. As the Commander of the Space Systems Division proceeds up the chain, he finds that space matters are a smaller and smaller part of the responsibilities of the officials who make the key decisions upon which he waits.

The budget for military space, hardly 4 percent of the yearly Defense outlays, must compete with a wide range of other Defense requirements, find its way through various layers of Air Force and Defense Department supervision, clothe itself to a large extent in secrecy, and come to the Congress not as a composite space package

but as various fragments in the category of research development test and evaluation. The committees of authorization and appropriation, confronted with the whole array of military matters in the \$50 billion Defense budget, cannot give military space the concentrated time and attention which NASA gets from its committees of assigned jurisdiction.

The fact that the Department of Defense cannot, as openly as NASA, publicize its space achievements and needs is a decided handicap. In part, this is an inevitable constraint upon all military activities. But the military, for obscure and unexplained reasons, have made a fetish of secrecy in some space programs to the point of seeming absurdity—so that even the names of projects which were once common currency in public discourse are now classified and cannot be openly mentioned. The aura of secrecy also veils unclassified projects, discouraging open discussion of fairly well known and by now commonplace matters. Meanwhile, the Government continues to release bits of information on launchings and other military space events, which are pieced together by trade publications and become the material for technical reports and commentary available to interested readers here and abroad.

The net result of the uneven classification of military space projects and the erratic policy of official concealment or disclosure, is confusion. The public is confused; often the Congress is, too; and no clear understanding is conveyed of what the military are or should be doing in space. The published accounts add to the confusion by combining meager facts with much speculation and inference.

The secrecy constraints, as presently applied, add substantially to the costs and burdens of program administration. They cause paperwork to multiply, since attempts to compartmentalize information require reproducing many extracts from classified documents. They also impede the transfer of technical data to scientists and engineers working in related fields, even when parts of the data are not sensitive.

The military bid for substantial participation in space experimentation also has been dampened in recent years by pronouncements at the Secretary of Defense level that the military have no clearly defined mission in space, particularly in the manned space flight area. These statements supposedly have no relation to such military functions in space as reconnaissance, nuclear detection, satellite communications, and navigation, but, again, the security policy does not make this distinction evident. The negative and self-defeating attitude toward military space missions is undergoing change, as we note below. Nevertheless, it has served to inhibit planning and development of new projects. In contrast to NASA's mission, which is as broad and boundless as space itself, the military seems to be caught at times in a vicious circle. Military space missions tend to be withheld until requirements are known, but requirements cannot clearly be known until space projects are executed.

The Defense budget for space is not insignificant; it amounts to approximately \$1.5 billion a year for the last few years. The level of activity also is high. The military had 50 earth orbital shots in 1964 as compared to 19 for NASA. In 1963 the military accounted for 50 of the 60 successful launches in the entire space program. The military space budget is about one-fourth the yearly obligations of NASA.

Some Defense spokesmen consider this sum is enough, as if there were some built-in assurance in budget figures. The real question is not the size of the budget but whether the military are being inhibited or prevented from engaging in those space activities which are essential to the long-range safety and security of the United States.

THE ISSUE OF THE MANNED ORBITAL LABORATORY

This question comes to a head in the recent controversy about the manned orbital laboratory (MOL). The effort would represent a sizable new commitment in space. The development and launching of the first series of manned orbital laboratories would cost at least a billion dollars, as estimated by military planners. References have been made to bigger space stations with longer orbital duration and more diverse and sophisticated experiments which would increase this order of cost fivefold or tenfold.

Is a manned orbital laboratory important for military purposes? The answer that came from the Department of Defense was affirmative but tentative. After cancellation of the Dyna-Soar orbital glider project in December 1963, Secretary McNamara announced plans for a military MOL. The importance of the MOL was explained in this way—that it was necessary to put men in space for an extended period and to conduct certain experiments in order to determine the military values of a manned space station. Significantly, this was a departure from earlier Defense pronouncements that the military had no clearly defined mission for men in space. Now at least Secretary McNamara showed himself willing to investigate the subject seriously. The commitment still is confined to the study phases, however; no final decisions for full-scale development have been made.

The other question is: Will a manned orbital station serve NASA's mission? There can be no doubt about it. The experiments to be conducted with a manned orbital station are, to a large extent, of considerable interest and importance to both the civilian and military agencies. Some experiments will have special military implications; others will produce scientific and technical information which is indistinguishable in the military or civilian sense. The behavior of men and machines at zero gravity, of fluids and gases, of propulsion systems, structures and materials—both agencies need and want to know about such matters. As knowledge is gained of the reactions and capabilities of men in the space environment, using their senses for observation and their brains for calculation and judgment, manipulating instruments, assembling and repairing structures and machines, inevitably the potentials for military application will emerge, even while the cause of science is advanced.

This mutuality of interest and the prospectively heavy cost of this new space venture have generated concern as well as confusion about each agency's plans and proposals and a move in some quarters to effect a "merger" of requirements in a single program or project to serve both NASA and the Defense Department. Both agencies have sponsored contract studies to gain a better understanding of the cost and technical dimensions and the design and management options in manned orbital stations.

NASA has projected its studies toward extensions of the Apollo project, sensitive to the need for developing new mission assignments

before Apollo approaches the completion phase, and hopeful that Apollo hardware and design data can be exploited, with appropriate modifications, to save some time and money in new space programs. Its budget request is \$50 million to conduct such studies in fiscal year 1966.

The Department of Defense lately is giving more emphasis to the "operational" potentials of an MOL, apparently to buttress the case for a military program in contrast to the "scientific" aspects of the NASA effort. Although the fiscal year 1966 Defense budget carries \$150 million for a military MOL, Secretary McNamara is withholding a final decision on MOL system design and hardware until program definition studies, contracted with four major companies, are completed and the results evaluated in conjunction with those derived from concurrent NASA studies.

The two agencies are committed to separate but interacting studies to determine what experiments each wants to conduct and the extent to which one agency can satisfy the needs of both in this venture. Secretary McNamara has said that these studies will provide a basis for judging whether a separate full-scale military program is justified. His decision is expected after June of this year.

THE CASE FOR A MILITARY MOL

We do not doubt that a soundly conceived program for a manned orbital laboratory with carefully devised experiments can serve both military and civil space requirements. The following questions then arise: (1) Can a single program fully serve both agencies' needs? (2) Which agency's needs have overriding priority? (3) Which agency shall manage and fund the program? (4) What hardware configurations should be used?

The inevitable answer to the first question, based on interagency experience in joint projects, is that compromises would have to be made in a single program. Cost, weight, and other constraints in spacecraft design would not permit both agencies to conduct all the experiments they desire in a single manned orbital station. The economies of a unified or joint program would have to be traded off against the limitations put on separate mission objectives and operating requirements.

The answer to the second question, in our judgment, points conclusively in the military direction. We reach this conclusion mainly on the conviction that the Soviet Union is substantially ahead of us in this field. The Voskhod launched in October 1964 was in certain respects a manned orbiting space station. Three men were in orbit for 24 hours, and they conducted experiments which we have yet to do. For example, the Russian astronauts were not confined to oxygen suits in their spacecraft, and the Soviets have shown in other ways their technical mastery of the space environment. In the latest demonstration, one of the two astronauts in Voskhod II, launched March 18, 1965, went outside the spacecraft and moved around in the space vacuum.

The answers to the third and fourth questions—which agency and what hardware—follow from the preceding considerations. It would be a serious mistake, in our judgment, for NASA to try to take on the complete management responsibility for a manned orbital laboratory

with overriding military objectives. The paramount mission of NASA at this time is to land a man on the moon before the Russians do. The urgent need for an MOL is to catch up with the Russians in technology which may have vital military significance. NASA should continue to concentrate on Apollo, and the Air Force should be commissioned, without further delay, to execute a full-scale MOL project, incorporating Air Force and Navy experiments as well as those of NASA.

The military MOL, under Air Force management, has this added advantage: It will energize and exercise Air Force resources for space management (reinforced by those of Aerospace Corp. and other technical support agencies to the Air Force) which have not been fully effective under prevailing DOD policies to restrict new projects or extend unduly the preliminary study phases. These military and technical support resources should not be allowed to deteriorate or be dissipated. They will be needed in the future, and their capabilities must be maintained for superior performance.

The indications are that the MOL under Air Force management will dictate the choice of the Titan III booster and the modified Gemini spacecraft rather than the Saturn booster and the Apollo system configuration. Both the Apollo and Gemini vehicle configurations have certain technical limitations for an optimum program of experiments conducted from an orbital laboratory or space station. However, NASA is heavily involved in the Apollo program and sees a ready means to adapt the Apollo hardware for space stations (Apollo extended system); while the Air Force has studied modifications of NASA's Gemini spacecraft and wants to find more uses for the Titan III booster, a development project approaching \$1 billion in cost. The impetus and direction of Air Force development studies to date would seem to militate against a shift of the military MOL from the Titan III and Gemini to the Apollo system.

In any case, a decision for full-scale development of the military MOL does not mean that NASA is preempted from future space station experiments under its own management. As we said before, which agency is to undertake a large new project cannot be intelligently determined on jurisdictional grounds but on a case-by-case basis, depending on practical considerations of on-going tasks, budgetary constraints and urgent needs. The future of space exploration will open up many requirements for manned orbiting space stations, and NASA will figure actively in developing new space projects. The imperative requirement as of now is to cover the gap in military space exploration, which the MOL promises to do.

The hesitancy, confusion, and delay afflicting the preliminary studies and planning for manned orbital laboratories or space stations cause the committee to emphasize again that planning for future space projects should not be on a hit-or-miss basis; that project developments should not reflect merely the outcome of interagency struggles and maneuvers to preempt a given field. In our view, a renewed attempt should be made, under the leadership of the National Aeronautics and Space Council, to formulate a national space program which will take full account of military and civilian agency needs and insure the effective use of all Government resources. We foresee that NASA will continue to be the major space agency, but that military activities in space will increase as the technology progresses; and that other civil-

ian agencies, such as the Atomic Energy Commission and the Department of Commerce, also will be substantially involved in space developments or operations.

TOWARD BETTER MANAGEMENT

When NASA was created, it absorbed the NACA functions and organization, still conducting aeronautical research, but charged with a much broader mandate in space research and exploration. The NACA concept of research in aeronautical systems short of engineering development and industrial applications was engulfed in the NASA commitment to build large space boosters and payloads and to carry developments in such fields as satellite communications and weather observations far along the road toward operational systems. In terms of facilities construction and hardware development, NASA became the biggest single rival and competitor of the mammoth Defense Establishment. It would not be, as NACA was, a research activity working mainly for the military. It would initiate its own programs, build its own facilities, develop its own procurement and management organizations superimposed upon the old NACA laboratories and field stations. Undoubtedly the cause for many of the headaches in NASA may be traced to the mixing of organizational forms old and new, retaining and expanding the old NACA research base for the development and management of sophisticated space systems.

In the old NACA organization, the aeronautical research effort was broken down by technologies, with laboratories for propulsion, aerodynamics, structures, and other segments. Within the laboratory for propulsion, for example, there was a further breakdown, with people working on compressors, pumps, burners, turbines, and the like. Cross-coupling or interaction at the lower levels of the research organization were at a minimum. The man working on turbines was not particularly concerned whether his results would be available on time to be used by the man working on wings. The researchers were highly specialized, dedicated to advancing their own specialties, and therefore more concerned with picking areas of high technological interest or payoff than contributing the components or subsystems for integrated system development.

NASA, the successor agency, has been striving diligently to overcome old handicaps in the organization of research disciplines and to meet new challenges signified by a budget which soon came to be a hundred times larger than that of the predecessor agency. NASA has sought the help of leading industrial executives and has experimented with successive internal organizations. Industrial contractor organizations have been hired for systems engineering and analysis as well as for hardware production. The old NACA laboratories or field centers for in-house research and technical management have been retained and expanded and new centers established.

One of the major problems of NASA is how to give strong management and direction to the all-demanding Apollo project without swamping the agency and drowning out other important functions such as aeronautical research as well as varied space missions. Another one is to lay a firm foundation for missions beyond Apollo which can make effective use of the agency's massive and widely dispersed

facilities and resources. Still another is to strike the proper balance between autonomy in the field and effective control at the top, insuring the exercise of initiative and management prerogatives in the field while preventing unnecessary overlapping and duplication among the centers.

In one sense, the problem of coordinating the NASA centers resembles that of coordinating the military services within the Department of Defense and mitigating the less useful consequences of interservice rivalry. In Defense, so far as space missions are concerned, evolving technology and organizational adjustments have done away with the more bitter manifestations of interservice conflict. The Air Force now has the primary space responsibility in the Defense Establishment, with the Navy, Army, and Advanced Research Projects Agency making important contributions. At one time the Army's resources and prospects for space exploration and development were large, but by transfers of Army resources to NASA under Presidential direction and reassignments of space responsibilities by the Secretary of Defense, the Army has been redirected from space to other concerns. Prevailing over its sister services for primary execution of space missions, the Air Force has developed an experienced management organization, with technical support from Aerospace Corp. and other nonprofit organizations which have among them an impressive combination of talents.

This is not to say that the Air Force has been free of its own organization and management problems; nor do we suggest invidious comparisons between NASA and the Air Force as concerns their ability to manage and conduct large development programs. Both depend, in the main, on the same industrial contractor base. While their policies and practices in procurement, management, and administration inevitably differ, NASA and the Department of Defense resort to joint or common directives or procedures when they deem appropriate, and they have developed a fair measure of cooperative working relationships. Technical failures, cost overruns, schedule slippages, and other problems beset both agencies, but the high priority of the Apollo project and the more generous funding of NASA activities enable NASA to carry such burdens more lightly.

NASA'S CRUCIAL TEST

The great and crucial test for NASA management is whether the lunar landing project can be kept on schedule and the costs held down to the \$20 billion estimate which has been repeatedly made by Administrator Webb. To keep reasonably within these time and cost estimates, development of systems, subsystems, and components must be directed and synchronized so that the whole program moves steadily and successfully toward its single objective. Long before the scheduled time for the lunar landing, it will be known whether NASA is meeting its planned commitments, and inevitably its management performance will be judged accordingly.

Only 7 years old and approaching the midcourse of its Apollo mission, NASA already has reached a stage of development when the size of its workload and budget compel increasing effort toward tighter and more efficient management. The Department of Defense has been experiencing such an evolution, more evident since 1961, when

Secretary McNamara and his Director for Defense Research and Engineering, Dr. Brown, took office. It is quite likely that NASA will take a similar course. The Office of the Associate Administrator, acting as general manager for NASA, may evolve into a management and control unit resembling the Directorate of Defense Research and Engineering. The NASA reorganization of 1963 makes this possible. Such a move promises greater uniformity of policy throughout the agency and a means of coping with strong tendencies toward autonomy and duplication among the field centers. A strengthened central office, staffed with persons of unusual competence who are enabled to relate programs into a coherent whole and resolve difficult problems of system choice and interaction, is a likely development in NASA's management.

Defense contracting methods developed or expanded under Secretary McNamara's direction also offer instructive example to NASA. Program definition studies, fixed-price and incentive contracts, value engineering, agency and contractor cost reduction programs, centralized audit, and contractor performance evaluation could be used by NASA to a greater extent with appreciable advantages. In some degree, NASA has utilized such methods. For example, in fiscal year 1964, about 60 percent of the agency's direct awards to business were made competitively, either through formal advertising or negotiation. NASA also is putting greater emphasis on incentive contracting, and 8 percent of its 1964 awards were in this category. Standardized contracting methods in common with the Department of Defense should be used as much as possible since both agencies use the same industrial contract or base. Thereby the procurement process can be made more efficient, with money savings to the Government, and more consistent and more harmonious Government-contractor relationships.

Entities outside the agency also can help to identify problems and their solution. These include the Congress, where oversight is a traditional duty. The General Accounting Office, as an arm of the Congress, also is beginning to find its way into the space program. In fiscal year 1964 the GAO made 3 audit reports to Congress on NASA management, as contrasted with 147 on the Department of Defense, but NASA can expect increasing attention by the GAO to its problems.

Oversight, however, should not work against NASA's authority and initiative in space research and development. The dangers of excessively tight management control, both from within and without the agency, and of imposing arbitrary budget ceilings, are not to be ignored. As NASA itself recognized when it began operations, research and development require initiative and relative freedom in order to flourish. The dangers are real, as evidenced by the excessive caution and restraint in the Defense Department regarding space missions. In Defense, the pendulum has swung too far in the direction of tight central management and supervision.

MAINTAINING A PIONEERING ATTITUDE

This is a paradoxical tendency in public management and one to be carefully watched. Secretary McNamara, in applying new and creative techniques of management to weed out old and prevent new

projects which are technically overambitious, extremely high in cost, and uncertain in performance, also has initiated tendencies which have a retarding effect on new developments. In space particularly there is a disposition not to authorize military programs unless there is a firm operational requirement, and absent such a requirement, the decision makers find that the easiest decision is to hold back or to do nothing. Protracted periods of indecision, covered by repeated studies and refined analyses, cause much lost time, much wasted human effort, and less progress. Without disparaging the value of cost effectiveness studies in given situations, we are certain that the United States cannot maintain world leadership in technology by unexceptional adherence to such concepts.

For the military to break out from present constraints on new technical enterprises, and for the Government to plan intelligently for its future space missions, it is important that the United States maintain a pioneering attitude toward new projects and advancing technologies. Unless we maintain leadership in such challenging fields as large rocket engines, supersonic transports, nuclear powerplants, and other fields, we risk severe setbacks to our position in world technology.

The pioneering attitude and the receptivity to large, bold new ventures demand, for effective expression, a highly developed sense of technological timing. For example, the orbital space station was technologically right for development at least a year ago. The same may be said of the operational communications satellite and the supersonic transport. The time constant for developing such systems is a period of years—in some cases 4 or 5, in others perhaps 7 or 8—but to achieve optimum results, the program must be started at the right technological time and performed within a period that accords with the time constant. Programs stretched over too many years tend to fail because the advance of technology makes the initially designed components obsolete before they are used. Programs attempted in too short a time often fail because the results simply cannot be achieved. Although judgments will differ, it is our belief that the race to the moon was properly timed for this decade, and it is also the right technological time to begin many more explorations of the military value of space.

ENGINEERING FOR ECONOMY

We believe, furthermore, that space technology, broadly considered, is reaching the stage when much more attention must be given to engineering for economy as well as for experimental performance. The first decade of the space age, which still has 2 years to run, has been characterized by frantic haste to beat or match the adversary by numerous technical innovations and crash-type programs. The one-shot throw-away booster philosophy, carried over from the missile developments, has prevailed. The fact that some of these shots propel human beings into orbit necessarily imposes severe and costly criteria for "man-rating" the boosting vehicle. Each launch requires extensive preparatory and followthrough operations, with armies of technicians and support elements.

As we approach the second decade of the space age, with many more launchings in prospect and a growing need for repetitive operations

rather than single shots, it seems to us that a new engineering philosophy ought to be developed—one that emphasizes recoverable and reusable boosters and spacecraft, standardization of systems and subsystems and components, multiple payloads per launch, less complicated and less costly ground support, and other technological and engineering developments conducive to more efficient and economical use of resources in a sector of Government operations which entails high costs and inevitably will expand.

This is the long view of economy potentials in space. Short-run economies must be sought in careful procurement, good management and improved interagency coordination. But these will be comparatively modest, considering the heavy commitments already made and the tasks of high national priority still to be done. Serious consideration also must be given to redirecting space technology for greater dividends in the future.

ORGANIZATION OF THE REPORT

In preparing this report, the subcommittee staff has drawn upon a wealth of material largely from official sources and public documents and from its own files developed in previous hearings and investigations. The present report is not a history of the U.S. space program. Necessarily it is selective, highlighting important developments and emphasizing matters of organization and management to which the committee gives continuing attention.

With its broad jurisdiction and concern with economy and efficiency at all levels of Government, the committee is in a good position to examine interagency relationships and multiagency disciplines and problems. Recent reports of the committee of such nature have been concerned with satellite communications² and weather programs.³

In the present report the committee centers its attention on the roles and relationships of NASA and DOD, which have the largest space budgets. We do not intend, by this emphasis, to slight the present and prospective interests in space of other Federal agencies which will become increasingly involved as developing space technologies show potentials for research and applications in pursuit of many governmental concerns.

We know that our readers will appreciate that a report of this nature cannot do justice to all the complex developments, to all the distinctive agency roles, and to all the important individual contributions in the space age. Within the limitations of our resources in staff and time, we have tried to be fair and accurate in presenting the facts, and to avoid distorted interpretations. The report, in draft form, has been carefully read by experts and informed observers in diverse fields encompassing the subject matter, to check facts and interpretations of complex events. For this assistance in reviewing the report, which has been generously given, the committee is indeed grateful. The evaluations and judgments, of course, are the committee's own.

The committee's recommendations are presented at the conclusion of this first section.

² H. Rept. No. 178, 89th Cong., 1st sess., entitled "Satellite Communications (Military-Civil Roles and Relationships)" (hereinafter cited as H. Rept. No. 178).

³ H. Rept. No. 177, 89th Cong., 1st sess., entitled "Government Weather Programs (Military and Civilian Operations and Research)" (hereinafter cited as H. Rept. No. 177).

Section II outlines early Government developments and activities in space, preceding the Sputnik event.

Section III reexamines the legislative and organizational issues leading to the creation of the National Aeronautics and Space Administration and bearing upon military-civil roles and relationships.

Section IV is an account of NASA's formative years, when large resources were acquired from the military agencies and initial efforts were made to develop space programs.

Section V describes the stepping up of the space effort with the lunar landing commitment and the civil and military agency reorganizations in response to new space age demands.

Section VI is an account of the reevaluations which began to take place as space programs reached peak levels of expenditure, followed by Defense Department restraint on military space ventures and increased demands for improved coordination between civilian and military space efforts.

Section VII examines the interagency coordinating mechanisms and problems.

Section VIII analyzes more closely the rationale for a civilian-military division of the effort.

The appendixes contain summary chronological data on civilian and military space budgets, organization charts to help in following some of the major reorganizations described in the report, and a list of the major agreements between NASA and the Department of Defense which have been reduced to writing.

RECOMMENDATIONS

Recommendation No. 1

The committee believes that in the interest of national security, the potential manned military uses of space deserve immediate increased attention. As a large step forward in exploring potential military uses, the Department of Defense should, without further delay, commence full-scale development of a manned orbital laboratory (MOL) project.

Recommendation No. 2

Pending the development of NASA's future plans and projects, appropriate arrangements should be made for NASA participation, through funding and selected experiments, in the Defense Department MOL project. The committee makes the above recommendation for a MOL without prejudice to NASA's future requirements for manned space stations, fully recognizing that space stations or laboratories will serve important civilian as well as military space purposes. The compelling need of the moment is to overcome a military lag in space technology.

Recommendation No. 3

A renewed attempt should be made at the Presidential level to formulate specific long-range national space plans. The parallel studies, competitive maneuvering, confused pronouncements, and potentially overlapping or duplicating plans by NASA and DOD for manned orbital projects strongly suggest the need for more orderly, systematic planning of future space projects on a national basis. To this end, the National Aeronautics and Space Council, chaired

by the Vice President, should be given the needed Presidential support and staff resources which will enable it to exercise greater initiative and execute its duties in the full range and broad intent of the National Aeronautics and Space Act.

Recommendation No. 4

Long-range planning for a balanced national space program must take account of these factors: (a) NASA will continue to be the leading agency for space exploration and development; (b) as space technology progresses, the military potentials will increasingly emerge and the military role will be correspondingly enlarged; and (c) other civilian agencies besides NASA, such as the Atomic Energy Commission and the Commerce Department, have important contributions to make to the national space effort. In assigning agency responsibilities, the Congress gave NASA a broad but not an exclusive responsibility in space research and development. It also gave full consideration to the fact that the Department of Defense would be actively involved and that other Government agencies would participate in space activities relevant to their missions and fields of interests.

Recommendation No. 5

The committee cautions against a too rigorous insistence that operational requirements be defined before permitting developments in new technological areas. These constraints tend to dry up initiative in the field, to inhibit new ideas at government and contractor sources, to create protracted uncertainties and delays, and to dissipate valuable technical resources. We cite military space development as a case in point, and we recommend that the Department of Defense take vigorous action to disassociate hard and fast military requirements from the new but rapidly growing area of space technology. Similar considerations should apply in the case of nuclear space developments.

Recommendation No. 6

In the interests of economy and efficiency, the committee urges that Government agencies involved in space, particularly NASA and DOD, use each other's facilities and resources to the greatest possible extent. Single management, standardization, and common use of ranges, control centers, tracking networks, and other ground support facilities and services should be encouraged in order to minimize costly duplication and the creation of separate additional facilities for each new program. Reimbursement principles should be clarified and updated.

Recommendation No. 7

To promote and guide coordination among the agencies, the committee recommends that the National Aeronautics and Space Council, under the leadership of the Vice President, serve as the focal point in reconciling interagency conflicts and in harmonizing relationships. A current registry of all written agreements for interagency cooperation should be maintained by the Council.

Recommendation No. 8

The committee recommends that NASA give increased careful attention to management techniques that have been developed in the Department of Defense and draw freely upon the wealth of military experience in procurement and management of large resources

and undertakings. The pursuit of economy and efficiency in Government operations in space involves internal management as well as interagency coordination. Each agency must have a zealous regard for careful procurement and good management, striving to insure timely performance, high reliability and reasonable costs.

Recommendation No. 9

The committee recommends that careful and intensive consideration be given to achieving future economies in space operations with greater standardization of systems and subsystems and through such techniques as recoverable and reusable boosters and spacecraft. The United States is and will continue to be heavily committed to space exploration and development. It is not too early to be concerned with the large money-savings potentials in advanced space technology.

Recommendation No. 10

The Department of Defense should pursue a more realistic security policy in its space program. The official public pretense that certain programs and requirements do not exist should be dropped. Normal classification standards should permit the identification of names and purposes of Defense space projects and launches. The need to restrict access to highly sensitive information should not affect aspects of the military space program not in that category. A broader dissemination of information on military space technology is necessary in the interests of more informed public support of military space efforts, visible and efficient management, and the application of military technology to the entire space program.

II. BEFORE SPUTNIK—THE ORIGINS OF GOVERNMENT SPACE ACTIVITIES

EARLY CIVIL-MILITARY RELATIONS

Sputnik I introduced the space age to a startled world on October 4, 1957. But present day space efforts in all their vastness and complexity cannot be truly understood without putting them in the context of pre-Sputnik activities and organizations. The history of the past reveals continuity as well as contrast with the present.

It is true that Sputnik aroused the United States to new and urgent efforts in space, overshadowing all prior activities of the Government. The challenge in space was indeed one demanding innovation and change, but governments traditionally do not meet even the newest of challenges by starting from scratch. Both logic and bureaucratic realities point to achieving continuity and to building on preexisting structures as much as possible. It was no mere coincidence that the National Aeronautics and Space Administration (NASA) was formed in 1958 around the nucleus of the old National Advisory Committee for Aeronautics (NACA), established in 1915. Similarly, the Act of Congress which chartered NASA also made provision for the continuation of Defense Department space activities, which, in rocketry at least, had been pursued by the military ever since the close of the Second World War.

Few of the activities of these agencies were directed consciously to the purposes of space exploration until the middle of the 1950's, when plans were made for U.S. participation in the International Geophysical Year. Yet the research and development pursued by these two governmental entities, whether deliberately related to space or not, were the necessary precursors to an active space program. Knowledge and experience gained in developing missile weapons, upper atmospheric sounding rockets, advanced high speed aerodynamic vehicles, nose cones capable of atmospheric reentry, and a host of electronic components and data relay subsystems found direct use in the space activities which were the product of a later and separate decision. Besides hardware development, the research conducted in and out of government for many years in atmospheric sciences, physics, radiation and astronomy also prepared the way for later space activities.

The connection between weapons systems and space systems probably was even more intimate in the Soviet Union, contributing to the Soviet lead demonstrated in 1957 and still being exploited today. The launching of Sputnik I confirmed the earlier boast of the Soviets, made in August 1957, that they possessed the means for delivering intercontinental ballistic missiles. By a strange turn of events, the Soviets actually had achieved a dramatic breakthrough in space because, conversely, they had not made the technological breakthrough in nuclear payload size as early as did the United States. The Soviets developed a huge rocket vehicle to carry the large nuclear

warhead to which they were restricted. The Soviets were then able to use their big rocket vehicle in launching large spacecraft and satellites.

By contrast, the United States had succeeded in scaling down the size of the warhead and thus developed a smaller rocket delivery system than the Russians. In addition, when the American satellite project for participation in the International Geophysical Year was initiated in 1955, a decision was made not to use a military missile development for a launch vehicle in order not to interfere with the missile program.

A significant aspect of the Soviet space program, then and now, is that there seems to be no separate civilian space organization as differentiated from a military program. The Soviets do have separate scientific advisory bodies similar to the American National Academy of Science, but program management for all space activities is apparently housed in one organization.

In the United States, on the other hand, space-related activities are lodged in separate organizations: The National Aeronautics and Space Administration and the Defense Department. Civil-military relations therefore are not new phenomena to be dealt with in managing Government operations in space. Traditionally these relations have been characterized by fairly close cooperation and have produced results mutually beneficial to both the military and the domestic spheres of interest. Substantial changes, however, have been wrought in organizational relationships and spheres of responsibility.

NACA FLIGHT RESEARCH

Up to and throughout the Second World War, NACA and the military services developed an organizational relationship along rather loose *ad hoc* lines. Personnel, facilities, and equipment were exchanged on almost a casual basis. To some extent this informal relationship was viable because during the war NACA worked for the military essentially on a support basis.

This support role was further amplified by the fact that the military services were represented as full members on the National Advisory Committee, which acted as a board of directors shaping the policy and supervising in a general way the activities and laboratories of NACA. These facilities and their work were under the immediate supervision of the Director of NACA.

This arrangement did not necessarily mean that the military services issued detailed requirements or specific work orders to NACA laboratories but, rather, that both agencies were sufficiently in contact with each other and with the overriding demands of the war that the flight problems needing solution flowed naturally to NACA. The services and NACA worked together to develop faster and better military aircraft. The particular responsibility of NACA was in the area of basic technology and advanced research. Using its extensive wind tunnel facilities and its highly trained engineers and scientists, NACA pioneered in formulating new aerodynamic theories and solving flight problems. The military services and industry took the job from there and designed and produced the airplanes. The result was Allied air superiority which contributed heavily to victory in World War II.

The airplane also provided the major impetus for the transition to rocketry. The need to push into the realm of transonic flight and beyond, and the example of German exploitation of its early jet- and rocket-propulsion experiments, impelled NACA and the military services into a cooperative venture which resulted in the X-series research aircraft.

The high-altitude research aircraft program was organized as a cooperative project, and the division of responsibilities was typical of NACA-military relationships in the early years.⁴ The Army Air Corps and the Navy funded the program, and NACA provided the technical supervision. NACA rarely funded a hardware project or got involved in big systems, in contrast to its successor agency, NASA. The job of building the test plane as well as initial testing was left to a private contractor. Following the contractor tests the Air Force and NACA jointly performed the flight research which was the object of the program. The military services concentrated on the area of potential military application, whereas NACA conducted highly instrumented and detailed flight research, reporting the results to the entire aircraft industry.

This cooperative interagency arrangement was given more formal and institutionalized status in 1946 when NACA signed an agreement with the military services, the Civil Aeronautics Administration, and various representatives of the aircraft industry. In a policy statement, entitled "National Aeronautical Research Policy,"⁵ NACA was assigned the task of fundamental research in the aeronautical sciences. Its programs, however, were to be formulated in close collaboration with technical personnel from all Government agencies involved.

By this agreement the design and development of equipment and aircraft were left to industry "assisted as may be necessary by contracts for experimental vehicles * * *." The military services were given the job of exploring the military applications of NACA research and were to use their own facilities to accomplish this task.

The revolutionary scientific applications to modern warfare developed during World War II were obviously fresh in the minds of the agreeing parties, who prefaced their policy statement with this comment:

The effects of accelerated enemy research and development in preparation for war helped to create an opportunity for aggression which was promptly exploited. This lesson is the most expensive we ever had to learn. We must make certain that we do not forget it.

Legislation also was enacted to formalize and tighten NACA-DOD relations. For example, explicit authority was given to the practice of transferring Defense materials and personnel. Another act of Congress increased the membership of the Advisory Committee from 15 to 17 persons, including the Chairman of the Research and Development Board of the Military Establishment. At the same

⁴ Kenneth S. Kleinknecht, "The Rocket Research Airplanes," The History of Rocket Technology (Eugene Emme, ed.), Detroit, 1964.

⁵ See testimony of Dr. Jerome C. Hunsaker in hearings on H.R. 5074 before Subcommittee No. 3 of the Committee on Armed Services, U.S. House of Representatives, 80th Cong., 2d sess., Feb. 20, 1950, pp. 5316-5318.

time the two Army Air Corps members were replaced by representatives of the newly established separate Department of the Air Force.⁶

It is significant of early NACA-DOD relations that in addition to the heavy military representation in the policymaking body of NACA, all this legislation was handled in Congress by the Armed Services Committees and was prefaced with the standard clause "to promote the national defense."

The first plane in the X series was the X-1. Bell Aircraft was awarded a contract in February 1945 to construct three research vehicles. The design and construction of the liquid-rocket powerplant for X-1 were performed under another Air Corps contract by Reaction Motors, Inc., first formed by colleagues of the American rocket pioneer, Dr. Robert H. Goddard. Concurrent with the development of the X-1 and as a second approach to transonic vehicles, a contract was awarded by the Navy Bureau of Weapons to the Douglas Aircraft Co. to design the D-558-I, an aircraft powered by a turbojet engine. This project provided a backup to the more difficult rocket development of the X-1. Later the D-558 project was modified to incorporate a rocket configuration.

ROCKET DEVELOPMENTS

The first of the X series aircraft and the D-558 project were justified primarily on the grounds of furthering aircraft design, and although many important innovations resulting from the research were incorporated into actual military aircraft, the contributions to the American rocket program and the later manned space projects were equally significant.

Efforts devoted directly to rocketry were initiated at about the same time the X series aircraft program began. In 1944 NACA established a Special Committee on Self-Propelled Guided Missiles for the purpose of recommending and coordinating research on missiles. In the following year Congress appropriated funds for expanded research in missiles at the NACA Langley Laboratory in Virginia and for the establishment of a rocket-launching facility at Wallops Island, also in Virginia.⁷

It was not until the war was over, however, that a rocket and missile program equivalent to the German effort during the war got underway in this country. Under Project Paperclip many of the German rocket experts, equipment, and data from Peenemünde were brought to America where at White Sands, N. Mex. the Army, under its Hermes program, with the assistance of the General Electric Co., assembled and tested 25 complete missiles from parts of partially completed V-2 rockets. The Hermes program and the Bumper project which followed it tested the feasibility of such concepts as airborne telemetry, flight control, and two-stage rockets. This important early work was the direct antecedent of later missile and space booster programs, including the Redstone, Jupiter, and Juno, developed when the V-2 team under Wernher von Braun was transferred to the Redstone Arsenal at Huntsville, Ala. This team is still largely intact at Hunts-

⁶ Ch. 645, sec. 2, 64 Stat. 418; ch. 335, sec. 1, 62 Stat. 266. For background information on NACA, see app. 2, "The National Space Program," H. Rept. No. 1758, 85th Cong., 2d sess., May 21, 1958 (hereinafter cited as H. Rept. No. 1758, 1958).

⁷ Eugene Emme, *Aeronautics and Astronautics, 1915-1960*, U.S. Government Printing Office, 1961, pp. 49-50.

ville but now engaged in NASA space projects as part of the George C. Marshall Space Center.

The Hermes program also contributed to the Air Force airbreathing intercontinental missile, Navaho, developed by the North American Aviation Co. Although that project ultimately was canceled, the rocket engine which launched the missile was the forerunner of almost all our present day missiles and space boosters.⁸

This early activity was accorded a very low priority in the years immediately following the close of World War II. The consensus of Defense Department and NACA scientists and engineers was that the problems of developing a true ballistic missile were too great to warrant full-scale activity. Many of the Nation's leading scientists considered the project a visionary one. The military consequently devoted most of its energies to furthering aircraft design, particularly jet-propelled vehicles. This thinking resulted in the official cancellation of the Convair long-range missile project, MX-774, only a year after it had begun in 1946. Fortunately for the nation, Convair continued to expend its own funds on the project. It was not until 1951 that the project was partially resurrected by the Government, and a decision to develop what became the Atlas missile did not come until 1953. As late as 1950 proponents of a larger and faster ballistic missile were literally "laughed out of the room" when they made their plea to the Air Force Scientific Advisory Board.⁹

The Navy also participated in early rocketry and space developments. Of particular significance for the future were the Navy experiments aimed at discovering more information about the region in which rockets and their payloads were to operate. Using both rockets and balloons during the early postwar years, the Navy, in cooperation with other agencies, pursued high-altitude research in order to gain basic information about the upper atmosphere and beyond, cosmic radiation, and high speed and altitude temperature phenomena.

The first of the Navy sounding rockets was the Aerobee, developed by the Applied Physics Laboratory and the Aerojet Corporation, starting in early 1946 and still being used today. A second and larger rocket, the Viking, was also initiated in early 1946. Designed by the Naval Research Laboratory (NRL) and developed by the Martin Co., the Viking saw additional service as one stage, together with an Aerobee stage, in the launch vehicle for the later Vanguard satellite of the NRL.

The basic scientific and research work carried on by NRL concurrent with its rocketry developments laid the foundations for many of the important scientific and technological achievements made by the American space program to date. Many of the scientists and project managers at NRL in the early days are now with NASA, occupying key positions in the space agency. One such former NRL scientist is Dr. Homer E. Newell, now Associate Administrator for Space Science and Applications in NASA.

Freed from the demands of war, NACA was able to carry on a more independent line of research and design than had been possible up to 1945. Nevertheless, even in the rocketry field NACA continued to emphasize military projects and devoted much of what can now be

⁸ Air Force and Space Digest, May 1964, pp. 63-69.

⁹ Ibid., pp. 58-67.

considered space-related work to solving particular military problems. At its research centers and field stations there was a heavy concentration on certain critical problems associated with missiles. The result of this concentration was extremely beneficial to the Defense Department.

In late 1945 the first launching of a two-stage rocket-propelled research model, the Tiamat missile, occurred at NACA's Wallops Island Station in Virginia. This feat was closely followed by the first successful use of a telemetry system, also in a Tiamat flight. In 1952 H. Julian Allen of NACA's Ames Laboratory conceived the "blunt type" nose cone principle as a means of solving the problem of reentry of a ballistic missile warhead. Allen's work led the way in showing that a reentry body could withstand the terrific heat generated by a missile's return through the earth's atmosphere. The blunt nose cone technique was later used in ICBM's and manned space capsules like Mercury.

As in the aeronautical field, NACA-DOD relationships in rocket work became more formalized. Interagency committees and agreements attempted to fix responsibilities and achieve coordination of agency efforts. But low priorities assigned to rocket programs and a splintering of projects hindered efforts to obtain an integrated, energetic program.

RESISTANCE TO SATELLITE PROPOSALS

If rocket and missile projects had tough sledding in the immediate postwar period, space programs never achieved approval even on the conceptual level until almost the middle of the 1950's. Although the feasibility of an earth-orbiting satellite officially was confirmed as early as 1945 by a group in the Navy Bureau of Aeronautics, no support was given to recommendations for constructing and launching such a vehicle.¹⁰ Navy representatives were successful in achieving a meeting of minds with Air Force counterparts on the desirability of a satellite program, but higher level approval in the Air Force was as impossible to obtain as it had been in the Navy. Undoubtedly the difficulty was in some measure due to the satellite proponents' concession that military advantages as yet were not apparent.

The Air Force would not give formal concurrence to Navy representations for a joint program based on its ideas for a single stage earth satellite, using liquid hydrogen-oxygen fuel, and later meetings bogged down when it became apparent that the Air Force wanted to insist on using the ideas proposed in its own Project Rand studies begun in 1946.

The Navy backers of a satellite project doggedly continued with limited study efforts until 1948, when all work was terminated due to a lack of funds. In the same year the Technical Evaluation Group of the Defense Department's Committee on Guided Missiles concluded, after studying both the Navy and Air Force Project Rand efforts, that "neither the Navy nor the U.S. Air Force has as yet established either a military or a scientific utility commensurate with the presently expected cost of a satellite vehicle."¹¹

¹⁰ The account of early satellite proposals is based on R. Cargill Hall, "Early U.S. Satellite Proposals," in "The History of Rocket Technology," cited supra.

¹¹ Aeronautics and Astronautics, 1915-60, p. 59.

This dismal conclusion was made despite prophetic warnings by the study groups of the consternation that would be felt in the United States if the country were to discover suddenly that some other nation already had put up a successful satellite. The same studies also had tried to demonstrate the feasibility and importance of satellites both for military and civil purposes. Chief among their proposed applications were communications and reconnaissance, which indeed have been proved by later developments to be of great importance.

The military scientists had no better luck interesting NACA in a satellite project. Again, the emphasis being given to advanced aircraft design was exploited as a possible entree into spacework. In late 1948 an ad hoc subcommittee in NACA was formed to explore methods of obtaining information on the upper atmosphere above 20,000 feet. The data was required to solve jet aircraft design problems associated with atmospheric drag and heating effects at high altitudes. The Navy single-stage rocket satellite was proposed as a sounding device to reach altitudes in excess of 400 miles. No approval was given to the idea, and satellite work virtually ceased until 1954.

Although NACA and the military services seemed seriously worried about reliving the experiences of the war, when accelerated research was forgone at the Nation's peril, the parties were countering this concern only in the aeronautical sciences, to which their policy statement cited above was addressed. Like military leaders who planned future battles on the basis of the war just past, the leaders of technology seemed to forget the real lesson that new frontiers of research posed the serious challenges. In this case the new frontier was space, and, once more, the expensive lesson had to be learned all over again.

INTERNATIONAL GEOPHYSICAL YEAR PROJECTS

Renewed interest in a space satellite did not develop until 1954, when discussions began on American participation in the International Geophysical Year (IGY) scheduled to run from July 1957 through December 1958. The effort was to be an international one, but there was no coordinated program agreed upon by all participating nations. An international committee of scientists did propose, however, that participants consider the launching of small satellite vehicles in order to obtain scientific information about the upper atmosphere. Although the Soviet Union was quite circumspect in its public descriptions of its plans, there were clear indications that it intended to orbit an earth satellite. In this connection it is worth noting that a Russian scientist, M. K. Tikhonravov declared publicly in 1951 that the U.S.S.R. could develop an earth satellite as part of a full-fledged space flight program. The statement went unnoticed.

The U.S. National Committee for International Geophysical Year, established under the auspices of the National Academy of Sciences, formed a study group to consider the feasibility of a satellite. Such a tentative step seemed to overlook the prior studies and calculations which as early as 1945 had confirmed the feasibility of the project.

Discussions between scientific personnel of the Office of Naval Research and the Army Ordnance Corps led to a proposal that a four-stage rocket based on the Army Redstone missile be built and fired into orbit with a 5-pound payload. This became known as Project

Orbiter. The top leadership of the Defense Department responded to the proposals by asking once more for further study. In part this cautious reaction was due to fear that a satellite project would fall victim to interservice rivalry. Consequently, orders went out that the project was to be "a strictly joint effort among the three services."¹²

Instead of achieving coordination, this directive might only have encouraged new interservice competition. In fact, by the spring of 1955, the Coordinating Committee, established by the Deputy Secretary of Defense, Donald Quarles, had before it three different satellite proposals of the services. In addition to Orbiter, there was a Navy proposal based on the use of a Viking rocket as the first stage of a three-stage launch system, and an Air Force alternative suggesting the use of the Atlas missile as booster and the Aerobee-Hi rocket as the second stage.

Faced with this impressive array of proposals and influenced no doubt by the need for backup plans to insure against failure, the Coordinating Committee recommended using all three approaches. Instead, another study panel was set up with instructions to define a program by July 1, 1955. The panel was chaired by Homer Joe Stewart, of the Jet Propulsion Laboratory.

The panel reported on August 4, 1955. Again no clear-cut recommendation was made due to conflicts in the Coordinating Committee. There was agreement, however, that the satellite program should not interfere with the ballistic missile program, which only recently had been given the full go-ahead and a top national priority. Consequently, although the Committee favored the Atlas approach as giving the greatest performance margin, the possible interference with the missile effort argued against this alternative. A majority recommended use of the Navy Viking rocket as the booster. The Army was quick to warn that the Viking required a major development effort, contending that the Redstone with modifications could orbit an 18-pound payload by January 1957.

The Research and Development Policy Council of DOD met on August 16, 1955, and decided to assign overall project responsibility to the Army, delegating to the Navy the specific task of developing the satellite. The Council quickly reversed itself in a subsequent meeting after the Stewart Committee objected to its recommendations and expressed doubt that the Army could make good its orbiting date of January 1, 1957. The Navy proposal was adopted, the Secretary of Defense concurring on September 9, 1955. The Secretary was particularly careful to point out that he wanted no interference with missile programs. The timetable was to achieve success by the end of the IGY or December 31, 1958.

Although an American space project had finally received approval, this single step represented no general attitude of enthusiasm by top officials for a vigorous, broad-gaged space program of the kind being secretly pursued by the Soviets. A lack of interest at the top level in the Defense Department was only partly compensated by service efforts. As the satellite problem demonstrated, each military service claimed a mission in space. Besides the Navy and Army activities mentioned above, the Air Force was also heavily involved. In fact, as early as 1949 a group of military and civilian aeromedical specialists, led by Dr. Hubertus Strughold at Randolph Air Force Base in Texas,

¹² H. Rept. No. 1121, 1059, p. 127 ff.

had started a Department of Space Medicine, which is continuing today to make important contributions to the entire space program. By 1957, Air Force planners considered that their plans for various space projects, including manned flights, had reached the stage where money in large sums was needed. Instead, a small amount was allocated for component development.

As can be gathered from the foregoing account, the indecision, rivalries, and bureaucratic tangles which had disturbed the missile program now began to have their first effects on the emerging space program. The vigor needed to push the program within the Defense Department was sapped further by the "purely scientific" label affixed to the Navy satellite development, named Project Vanguard.

The tendency to consider Vanguard as something removed from the usual military considerations and, thus, from any sense of urgency was reflected by a statement of a Navy spokesman, made when the project was underway:¹³

Sponsored by the Department of Defense and executed by the Naval Research Laboratory, Vanguard nonetheless has always been a scientific project, distinct from any military programs.

Whatever might have been the motivation, Vanguard proceeded throughout 1956 and 1957 under a low level of funding, loose management procedures, and a certain amount of division in responsibilities.

REACTION TO SPUTNIK

All this changed with the electrifying news on the morning of October 4, 1957, that the Soviet Union had successfully launched the first artificial satellite. It was clear then that the Russians in their program had made no distinction between "military" and "scientific" projects as had the Americans. The 4 tons of total payload in the Sputnik I shot, including 184 pounds of instrumentation, contrasted dramatically with the American plans for a Vanguard satellite with a total payload weighing only 3 pounds. This accomplishment indicated clearly that the Soviets also possessed the technology for an intercontinental ballistic missile system as well as a highly advanced space program.

Significantly, the United States finally achieved its first space success by drawing upon military resources. The Army Ballistic Missile Agency, using its Jupiter C as a launch vehicle, placed the Explorer I satellite into orbit on January 31, 1958, 84 days after the Army project had been hastily approved in the wake of the Soviet Sputnik. The Vanguard, with its relatively new launch system, deliberately had been selected because it was not a part of the military missile family. Vanguard finally succeeded, after several failures, on March 17, 1958, two and a half years after its official inception. This success, it should be recognized, still came well within the original schedule. The scientific and technological contributions made by the Vanguard program were important ones and still rank among the more significant landmarks of our national space effort to date. Observation of the orbit of Vanguard I resulted in a discovery that the earth was somewhat pear shaped. This and other scientific discoveries proved the

¹³ Statement submitted to the Military Operations Subcommittee of this committee in hearings on "Organization and Management of Missile Programs," 86th Cong., 1st sess., February-March 1959, p. 435.

worth of Vanguard to the purposes of the International Geophysical Year for which the system was designed. The satellite also served as the model for later scientific and applications satellites, and the launch vehicle was the predecessor of many follow-on vehicles. The NASA Delta, using improved Vanguard second and third stages, has become one of the most successful boosters in the NASA launch vehicle stable.

Fault, therefore, cannot be attributed to the system or its developers but to the decisions, priorities, and organizational structures which represented the meager American space effort before Sputnik.¹⁴

The fundamental effect of the concern generated by the Russian success was recognition within the Government that the entire spectrum of space technology had to be given the same high priority afforded the ballistic missile program. A high priority space program in turn called for strong, new Government organizations.

¹⁴ See staff report on Project Vanguard, in hearings on DOD appropriations for 1960 before Subcommittee of Committee on Appropriations, U.S. House of Representatives, pt. 6, 86th Cong., 1st sess., p. 53 ff.

III. ORGANIZING FOR SPACE: 1957-58

ADVANCED RESEARCH PROJECTS AGENCY

As a first step in reorganizing the Government for space activities, Secretary of Defense Neil H. McElroy announced in the late fall of 1957 his intention to create within the Department of Defense a new agency which would take over "all our effort in the satellite and space research field." At first called the Special Projects Agency, the new organization was established at a level above and distinct from the three military departments.¹⁵

The broad sweep of the new Agency's proposed authority in space conveyed by the Secretary's original announcement was watered down during the process of clarifying the responsibilities of the new organization. The thrust of its jurisdiction was indicated by the name it eventually acquired, the Advanced Research Projects Agency (ARPA).

A rationale obviously was needed for the decision to remove certain responsibilities for development of space technology from the military services. Hence, the new Agency was described as having "single control in some of our most advanced development projects," leaving to the services the task of research and development of weapons systems "which fall clearly within the missions of any one of the military departments."¹⁶ This distinction, though not clear, served several objectives of the administration. It removed from space technology the previous handicap of low military priorities due to apparent lack of immediate weapons system application. At the same time, the problem of interservice rivalry was for the time being avoided by placing in a body removed from the individual services the power of decision over initiation and direction of space projects.

President Eisenhower, in his State of the Union message on January 9, 1958, made more explicit the meaning of the term "advanced projects" when he stated that the new Agency represented a decision "to concentrate into one organization all the antimissile and satellite technology undertaken within the Department of Defense."¹⁷

The Armed Services Committees of Congress were apprehensive about possible diminution of the roles of the military services and the potential increase in the Secretary of Defense's powers, which they sought traditionally to keep within careful bounds, particularly when reorganization was involved. Accordingly, when the military construction bill for 1958 was enacted into law, it carried language which avoided specific reference to ARPA as an organization, but did authorize the Secretary to conduct under his own direction or that of his designee advanced research and development projects. The Secretary was allowed to determine which projects were to be pursued as advanced projects under his direction, with the proviso that such determinations were to be made only after consultation with the Joint

¹⁵ H. Rept. No. 1121, 1959, p. 133.

¹⁶ *Ibid.*

¹⁷ H. Doc. No. 251, 85th Cong., 2d sess.

Chiefs of Staff. In addition, projects could be designated directly by the President for a 1-year period.

To assure service participation and authority, the act stipulated that:¹⁸

Nothing in this provision of law shall preclude the Secretary of Defense from assigning to the military departments the duty of engaging in research and development of weapons systems necessary to fulfill the combatant functions assigned by law to such military departments.

Continuity with traditional ways of doing business within the Department of Defense earlier had been promised by the Secretary when he told Congress that the ARPA program would "be developed in coordination with the military departments to the point of operational use, so that they may be phased into the operation of one or more of the military services with a minimum loss of time or interruption of development and production * * *"¹⁹

In approving the request for a \$10 million fund transfer to ARPA, the House Appropriations Committee was more concerned that the new tasks be done quickly and efficiently. Its report on the supplemental appropriations bill of 1958 warned:²⁰

If it is to be successful the Advanced Research Projects Agency must not be allowed to become just another layer of paperwork in the Office of the Secretary of Defense. It must be clothed with the authority and the control of funds necessary to conceive, coordinate, and implement research and development of essential programs * * *.

In fact, there was a compromise between old and new methods. The execution of many of the projects in the expanded space program was left to the services, which possessed the required personnel, resources, and experience to do the job, having acquired them during the course of the missile programs and the Vanguard and Explorer projects. These resources included launch stands and rocket vehicles, tracking networks, laboratories and test facilities. ARPA accordingly designated the military services as its executive agents on many projects.

On the other hand, it was clear from the outset that ARPA's novel location within the structure of the Defense Department plus its authority to contract directly with private industry gave the new Agency the potential for exercising a high level of initiative and control. Reporting only to the Secretary of Defense, the Director of ARPA was given access to facilities and resources other than those of the military services. His charter gave him power to contract with other Government agencies as well as with private companies and universities. The Director could also acquire or construct his own facilities, although a policy statement accompanying the new charter stated that ARPA "for the present" would neither acquire nor operate its own facilities.²¹

The new Agency moved quickly in the first months of its existence to show that it intended to exercise its broad jurisdiction for all

¹⁸ 72 Stat. 11, Public Law 85-325, sec. 7.

¹⁹ H. Rept. No. 1121, 1959, p. 134.

²⁰ H. Rept. No. 1288, 85th Cong., 2d sess.

²¹ H. Rept. No. 1121, 1959, p. 136.

space activities. In early 1958 ARPA initiated research and development on reconnaissance, weather and communications satellites, solid propulsion, reentry phenomena, space tracking and detection. The reentry research was related to an Air Force project, the Dyna-Soar orbital glider development. ARPA and the Air Force also took the first steps aimed at launching a man in space, and to overcome the Soviet lead in big boosters, the Air Force began development of a single chamber rocket engine capable of a million and a half pounds of thrust. The administration indicated that ARPA, despite its location in the Defense Department, would in fact be a prime mover for all types of space projects, even those which might be considered by some as having no military requirement. At that time there was little apparent concern in administration circles about defining the scope of the new Agency's work program. The overriding consideration, reflecting the alarmed mood of the country after Sputnik, was to act quickly to counter the initial advantage gained by the Soviets.

As a result, the President authorized ARPA to initiate a lunar probe program, employing the resources available in the military services. The probe was to be achieved by using Army and Air Force booster developments, the Jupiter and Thor. The assignment was an expedient one, but already steps were in motion that would prove ARPA's broad jurisdiction in space to be temporary.

PROPOSALS FOR AN INDEPENDENT SPACE AGENCY

In the closing months of 1957 the "Sputnik crisis" was of such proportions that a more sweeping and radical reorganization than that envisioned by the creation of ARPA was demanded in many quarters both within and without the Government. Some of these demands originated in Congress, where ultimately the final decision would be made. One of the first congressional committees to deal with the space crisis was the Preparedness Investigating Subcommittee of the Senate Committee on Armed Services. Chaired by the then majority leader of the Senate, Lyndon B. Johnson, the subcommittee began extensive hearings on November 25, 1957.

The vast amount of testimony gathered by the subcommittee dealt largely with the relative standing of the United States and the Soviet Union in rocketry, missiles, and bombers. Despite the committee's emphasis on the military problem, the final recommendations focused on the long-range needs of space research and development from a broad national point of view. To meet these needs the subcommittee urged improved control and administration within the Defense Department or the establishment of an independent agency.²²

Sentiment for a new agency which would concentrate on long-term research and development in space was shared by a growing number of persons in positions of leadership and influence. Almost from the beginning of the debate, there was general agreement that activities of the kind pursued during the IGY, such as Vanguard, more properly should be handled outside the Defense Department. This attitude reflected a natural reaction to the experience of Vanguard, which suffered from a lack of high priority within the military program

²² Congressional Record, Jan. 23, 1958, pp. 905-907.

rather than from any defect inherent in military technological management.

Some of the first concrete suggestions for the creation of a new space agency were put forward by various technical organizations. The American Rocket Society presented to President Eisenhower, only a week after the Sputnik launch, a proposal for the establishment of an Astronautical Research and Development Agency, similar to the National Advisory Committee for Aeronautics, which would have the responsibility for all space projects except those directly related to the military.²³

The President himself reached out to the scientific community for help when on November 7, 1957, he created the post of Special Assistant to the President for Science and Technology. Dr. James R. Killian, Jr., president of the Massachusetts Institute of Technology (MIT), was appointed to the job. He soon established himself in the administration as the focal point for the planning of the future space organization.

NACA also broadened its base of support and advice from the scientific community. On November 21, 1957, the main committee of NACA authorized establishment of a special committee on space technology. Chaired by Dr. H. G. Stever, also from MIT, the new committee was charged with taking a fresh look at the research and development problems of space technology and making recommendations as to needed programs.²⁴

Budget levels, however, restricted NACA from making dramatic increases in space programs. The President's budget request for fiscal year 1959 indicated that supplemental funds would be sought for the current fiscal year. The amount was unspecified at the time of the budget message in early January 1958. The only figures then released indicated a level of expenditures for NACA in fiscal year 1959 of \$101 million, as contrasted with a request of \$340 million for ARPA. Such a spending level for NACA was a significant but modest increase over prior expenditures, which had been running at approximately \$70 million.²⁵ Later legislation creating NASA changed the entire situation radically.

NACA could not speak too forcefully in public about the need for reorganization of Government space activities. The agency did release a staff study on January 14, 1958, entitled "A National Research Program for Space Technology," which recommended an interagency cooperative space program embracing NACA, DOD, the National Science Foundation, and the National Academy of Sciences. Exactly how these programs would be managed and what would be the division of responsibilities were questions left unanswered.

The staff study, as well as a resolution on space flight adopted by the main committee on January 16, 1958, were firm on the point that basic scientific research on upper atmosphere and space phenomena should be conducted by NACA rather than by the military.²⁶ This suggestion mirrored the growing demand in scientific and other circles that steps be taken to insure that not all space research be lodged in the Defense program, where military requirements might

²³ Compilation of Materials on Space and Astronautics, No. 2, committee print. Special Committee on Space and Astronautics, U.S. Senate, 85th Cong., 2d sess., Apr. 14, 1958, p. 300 (hereinafter cited as *Compilation of Materials on Space, 1958*).

²⁴ H. Rept. No. 1758, 1958, p. 219.

²⁵ The Federal Budget in Brief, Fiscal Year 1959, GPO, pp. 9, 45; The Budget of the U.S. Government, Fiscal Year 1959, GPO, pp. 101, 169, 438.

²⁶ H. Rept. No. 1758, 1958, pp. 115, 117.

distort or reduce the scale of scientific programs. Insofar as this sentiment was taken to mean there should be separate military and civilian efforts, the demands were both understandable and correct; but, unfortunately, the space age debate began to suffer from an unnatural polarization of military and scientific programs, as if they were opposed technologies. Still worse was the growing tendency to talk in terms of military as distinguished from peaceful space programs.

CONGRESSIONAL ACTION

There was a flood of legislative proposals placed in the bill hopper in the first days after Congress reconvened in 1958. Most of these proposals suggested Government-wide innovations to deal with the broad problems posed by the new technological challenge. Many bills required new organizations carrying a label other than exclusively space: Department for Research and Development, Department of Science and Technology, National Science Council, and so forth. Some bills were designed to have a single organization directing all space activities, while others dealt only with so-called civilian scientific functions.

The language of many of these bills embodied specific recommendations for placing all the scientific activities of the Government in one organization, including, in addition to space projects, the programs of such organizations as the National Science Foundation, the Commerce Department, and the Smithsonian Institution. Almost all proposals, however, carried implicit recognition of the need to build any new agency on a solid foundation of past experience and pre-existing organizational structure.

Out of this welter of proposals and bills, the Congress had to determine the best approach and to write specific legislation. On February 6, 1958, the Senate passed Senate Resolution 256 creating a Special Committee on Space and Astronautics. The resolution was the outgrowth of the work done by the Preparedness Investigating Subcommittee. Similarly, the House of Representatives established its own Select Committee on Astronautics and Space Exploration.

Evidence of the high degree of importance placed by Congress on the task ahead was the selection of the majority leaders of both bodies as the chairmen of the new committees, John W. McCormack in the House and Lyndon B. Johnson in the Senate.

Although a large number of bills was referred to both committees, hearings did not begin until the administration submitted its own proposal on April 14, 1958. The delay was inevitable, since important organizational decisions were at stake, and many existing agencies which would be affected wanted to be heard in the highest councils close to the President where the drafting of the proposal took place.

THE MILITARY ISSUE

The chronology of events in early 1958 also suggests that considerations other than obtaining agency views delayed the formulation of the administration space proposal. These considerations related to the problem of disarmament, which received a renewed amount of attention at that time. The communications between the United States and the Soviet Union conceivably had a bearing on the organization of the American space effort and, therefore, they must be

studied for their possible contribution to the concepts embodied in later executive and legislative actions.

In his State of the Union message of January 10, 1957, President Eisenhower had said that the United States was "willing to enter any reliable agreement which would * * * mutually control the outer space missile and satellite development." Exactly a year later, the President responded to suggestions from Soviet Premier Bulganin for a summit conference to discuss, among other matters, disarmament. In his response, Mr. Eisenhower proposed that the two nations "agree that outer space shall be used only for peaceful purposes."²⁷

The Soviets interpreted this proposal to mean banning the use of outer space for military purposes. They agreed that this might be a good idea to discuss but only after the United States had liquidated its foreign bases. It is interesting to note that the day after the President received this rebuff, he directed Dr. Killian to make specific recommendations to him on the Government organization of space activities.²⁸

One could speculate as to the military role in the organization or prosecution of space activities had the President received a favorable response to his proposal from the Russians. In any case, the President did decide to retain Defense Department participation in space activities. The question then became how much and what kind of participation. The President, it is known, wanted to avoid expensive duplication of effort, and he also listened to advice cautioning him about the danger of military domination of space activities.²⁹ Public debate and commentary often made it appear that there was a controversy within the Government much like that which raged during the creation of the Atomic Energy Commission, with some persons arguing for total control of the space program by a civil agency and others wanting everything in the hands of the military.

The real issue within the Government was not whether to have a military or a civilian space effort, but to create suitable arrangements for both. Changes in the organization of space activities were required, it was generally recognized, and there were inevitable differences of opinion as to exactly what changes should be made.

Some officials, particularly those within the Pentagon, expected that the changes would not be drastic. These expectations were nurtured by the existence of ARPA with its growing list of space plans and by the disposition in Government to build a new space entity upon the resources and experience of NACA, which had satisfactory working relationships with the military. If NACA were taken as the model for a new agency, the job of developing and procuring space hardware would remain in military hands. Moreover, the military would be represented on the "Board of Directors" of the agency as they were on the main committee of NACA, thus having a voice in the selection and execution of space projects, even those of a scientific or applied research variety to be pursued by the laboratories and facilities of the new agency.

Early statements of NACA, already mentioned above, were subject to the interpretation that NACA would not be adverse to continuing such an arrangement, but a close reading of these statements also

²⁷ Compilation of Materials on Space, 1956, pp. 359, 363.

²⁸ Id., p. 368; H. Rept. No. 1758, 1958, pp. 222-23.

²⁹ Sherman Adams, "Firsthand Report," New York, 1961, pp. 414-417.

reveals a desire to break new ground. For instance, in the staff study released on January 14, 1958, NACA at one point stated: "The pattern to be followed is that already developed by the NACA and the military services." At another point, in discussing the need for new space vehicles to explore the phenomena of the upper atmosphere and space, the statement advised:³⁰

In order to avoid confusion and unnecessary duplication of facilities, the responsibility for making space flights for this scientific research should rest with the NACA. It would be the duty of the NACA to provide the flights and to assist in all possible ways in obtaining the required data, but financial support of the basic research programs should rest with the National Science Foundation.

This could be interpreted to mean that the military services would continue to procure the vehicles and also share in the flight program, as they did in the X-15 program. Such an interpretation is supported by the final sentence in the statement that the "flights should be conducted by the appropriate agencies of the Department of Defense and the National Advisory Committee for Aeronautics in the successful pattern of the research airplane programs." Nevertheless, the idea of funding by the National Science Foundation might have indicated a desire by NACA to depart from its reliance on the military for support funds and procurement.

Despite the ambiguities of this statement, the suggestions pointed more to an expansion of NACA than to the creation of a new agency. This same attitude was reflected in a speech delivered for Dr. Hugh Dryden, the Director of NACA, on January 27, 1958.³¹ Urging a greater emphasis on space research, Dr. Dryden drew a distinction between research in space technology, including development of manned and unmanned space vehicles, and research on space phenomena, such as the character of matter, cosmic and solar radiation, magnetic and gravitational fields, and other scientific aspects of the universe. It was the second category, he said, which induced recommendations for a new space agency:

The basic reason underlying these proposals for a new civilian agency is plain. The scientific community, understandably, is worried about the possibility that the extremely important nonmilitary aspects of space technology would be submerged, or perhaps even lost, if included as a mere adjunct to a military program.

Dr. Dryden believed that this concern could be satisfied as well by expanding NACA, which, he said, had long experience in handling the dual civilian-military functions of technology. Again, however, there emerged an ambiguity as to future space operations:

The NACA would conduct flights for scientific purposes when within its capabilities, or jointly with appropriate agencies of the Department of Defense, in the successful pattern of the research airplane programs. The NACA would also coordinate and conduct research in

³⁰ H. Rept. No. 1758, 1958, p. 116.

³¹ Id., p. 110.

space technology in its own laboratories and by contract in support of both military and nonmilitary projects.

If such an approach were followed, the expanded NACA might develop hardware as well as conduct research. Research would also be conducted for the military, but such work would not be incompatible with research performed directly by the Defense Department. The statement also implied that NACA would not develop and procure military space hardware.

THE ADMINISTRATION BILL

The final form of Administration bill demonstrated an attempt to balance the structure of Government space activity.³² Still, the proposed language caused immediate problems, partly because the compromise seemed too strained and partly because new pathways were left unclear.

The unwieldy declaration of policy contained in section 2 of the Administration bill suggested several of these problems:

The Congress hereby declares that the general welfare and security of the United States require that adequate provision be made for research into, and the solution of, problems of flight within and outside the earth's atmosphere and that provision also be made for the development, testing, and operation for research purposes of aircraft, missiles, satellites, and other space vehicles, manned and unmanned, together with associated equipment and devices. The Congress further declares that such activities should be directed by a civilian agency exercising control over aeronautical and space research sponsored by the United States, except insofar as such activities may be peculiar to or primarily associated with weapons systems or military operations, in which case the agency may act in cooperation with, or on behalf of, the Department of Defense * * *.

By this draft bill the President indicated that he wanted a new organization, called the National Aeronautics and Space Agency, which as a full-fledged civil agency would be the prime mover in Government space activities. In support of this decision the bill gave authority to the new agency to develop vehicles, acquire facilities and property, contract, hire without regard to civil service laws, and take over functions and programs of other agencies. These were proposals for big and important advances but other aspects of the bill retained old arrangements.

For instance, although the proposed new agency would be fully constituted, with its director appointed by the President and with the powers enumerated above, the old NACA structure would be absorbed and perpetuated within the new organization. Furthermore, the new agency would continue to be subject to a policymaking board composed of private and Government figures, including a Defense Department representative. This board would not only advise the new agency concerning policies and programs but would also require that the agency consult with it prior to the initiation of

³² H. R. 11681, 85th Cong., 2d sess. (See H. Rept. No. 1758, 1958 p. 65.)

programs, transmittal of budget requests, establishment of major agency units, and the appointment of the heads of such units.

The degree to which military functions and programs would be affected was not made clear. In one sense, the declaration of policy entitled the Defense Department to continue space projects, but this was specified as an exception in the language of section 2. Such phraseology raised a presumption in favor of future allocation of major space work to the new agency. This language was preserved in the final act and events have worked in favor of such a presumption.

The exception was further narrowed by the words limiting the Defense Department to "activities * * * peculiar to or primarily associated with weapons systems or military operations." This was in contrast to the emphasis on broad research powers given to the new civilian agency. The President had described his bill as giving to the new agency the authority to conduct "purely scientific" work.³³

The proposed division of labor signified exclusion of the military from research and development in broad space technology while limiting the new agency to such research alone. Did this mean that the new agency was only to conduct research and the military was to deal only in the practical applications of research already concluded? If so, did this delineation create an unworkable dichotomy between "pure science" and operating military systems?

The problems did not stop there. No matter what might be the specific authority given to the military, the exception clause carried the further qualifying language that in the case of military projects "the agency may act in cooperation with, or on behalf of, the Department of Defense." Did this mean the new civilian agency would undertake military projects? Did it require the approval of the agency before space work was done by the Defense Department?

There were other questions. The section giving authority to transfer the functions, facilities, and programs of Government agencies, including the Defense Department, to the new organization did not specify the functions and projects. Furthermore, such transfers were subject to the concurrence of the department concerned, a possible handicap in the move to reorganize the space effort.

The vagueness of these provisions suggests that dividing the labor between civilian and military agencies was no easier a job in 1958 than it is today. The problem is not susceptible to clear, fixed principles established in advance. As was pointed out in an early staff paper prepared for the House committee, "Practically every peaceful use of outer space appears to have a military application. For example, the military establishment is concerned with weather control, all forms of communications, reconnaissance satellites for mapping, and even medical research on weightlessness has implications for satellite weapons."³⁴

ATTEMPTS TO FIX CIVIL-MILITARY JURISDICTIONS

This inevitable overlapping invited attempts to fix organizational relationships and agency functions with more exactness in legislation. On this issue the Defense officials were still concerned enough to object publicly to the exception clause of the administration bill during the

³³ New York Times, Mar. 30, 1958, p. 1.

³⁴ Eilene Galloway, "The Problems of Congress in Formulating Outer-Space Legislation," in hearings on H. R. 11681 of the Select Committee on Astronautics and Space Exploration, U.S. House of Representatives, 85th Cong., 2d sess., April-May 1958, pp. 5, 8.

first days of hearings. Roy Johnson, the newly appointed Director of ARPA, strenuously objected to any interpretation which might give the new agency veto power over the military or restrict the Defense Department to operating systems.

Defense objections were not stilled when it was proposed to modify this section to specify that space activities be directed "by a civilian agency which shall exercise control over aeronautical and space research and development sponsored by the United States and which shall act in full cooperation with the Department of Defense insofar as such activities are peculiar to or primarily associated with weapons systems." In replying to this proposed change, Dr. Herbert York, then Chief Scientist for ARPA, said:³⁵

It sounds as though they are in charge but they are supposed to cooperate with us. Space is a place and not a program * * *. In this country I do not think we consider that the ocean belongs to the Maritime Commission and the Navy has to get permission to operate there. The same way with space. If the DOD wants to put up reconnaissance satellites, I don't see why the civilian agency should have anything to say about it. The reconnaissance satellites are for military purposes. They are flying through space and operate in space but it seems to me they are military from start to finish.

The House Committee attempted to write into the bill specific language giving the Defense Department clear authority to conduct supporting research and development. The administration objected that such wording would be too "elastic." An administration spokesman argued that language specifically covering any and all kinds of work would make it seem "as if we are trying to take this away from civilian control."³⁶

The agencies, enmeshed in their own jurisdictional concerns, did not manifest any apprehension over the apparent lack of machinery in the administration bill for coordinating the separate efforts or for resolving jurisdictional disputes. The Congress on its own became increasingly anxious about potential gaps in the bill and sought to fill them. The hearings first probed the reasons for the lack of administration concern with this problem.

PROVIDING FOR INTERAGENCY COORDINATION

Witnesses representing Defense and NACA were confident that the civilian and military organizations could proceed independently without disputes and without a higher-level coordinating body. This confidence stemmed from their apparent success in effecting an initial division of labor.

Roy Johnson of ARPA told the House committee about an understanding reached between the two groups which would give the new space agency responsibility for so-called civilian activities: "unmanned space flights to obtain scientific data, such as vertical probes, lunar and interplanetary probes, scientific satellites with associated data acquisition and analysis." This statement meant that Defense

³⁵ *Id.*, p. 1533.

³⁶ *Id.*, p. 1534.

would transfer to the new agency the Vanguard, Explorer and lunar probe projects. Defense would retain certain systems development projects, including the reconnaissance and communications satellites and the orbital glider.³⁷

From this list it was easy to see why the agency witnesses were confident there would be no serious problem resolving future disputes. First of all, the agencies had dealt only with projects in being or in the planning stage. Secondly, these projects could not be readily associated with urgent military requirements. Lastly, the proposed division of labor was in the tradition of NACA-DOD relations, although it was illusory to suppose that the administration meant to compartmentalize space activities along the old lines. If carried forward, this division would result in the new agency's doing only the work of scientific research and exploration in space, and DOD the hardware applications.

But what about the host of projects only then emerging from the concept state in ARPA, such as the man-in-space project, space stations, weather satellites, and others? Although the future of such projects was somewhat uncertain, the Defense Department undoubtedly considered that it had control over the situation by virtue of the provision in the administration bill requiring the concurrence of the Department before projects were transferred.

Another reason for Defense Department complacency about future problems of jurisdiction was its apparent belief that military representatives on the proposed Board would retain a powerful voice in the planning of the new agency program, just as they had in NACA. Actually, only 1 DOD representative was required in the 17-member Board, but there was no maximum put on the number of DOD members among the 8 Government representatives.

Whatever might be the extent of Defense representation on the Board, it was an unsettled question as to how much authority was given the Board. The administration bill required the Director of the new Agency to consult with the Board, but it did not direct him to take the Board's advice. The Director of the Agency might very well say that the legislation made him the man in charge. Other agencies might respond by claiming that the Board was the ultimate authority. As a result of this potential conflict, the bill was soon criticized as being weak in its delegation of powers.

The chairman of the Senate committee, Lyndon Johnson, declared that as the bill stood it presupposed a "get along policy which I think is very optimistic." Unhappy with the split authority in the bill, he stated during the Senate hearings:³⁸

I think we are either going to have to have a board with some authority, a committee that says "here is what you can do and what you can't do, and here is what your function is" or we are going to turn it over to existing agencies or some specific agency where authority and responsibility go together.

Resolving the internal management problem would not, however, resolve the jurisdictional problem between agencies. For this the

³⁷ *Id.*, p. 1529.

³⁸ Hearings on S. 3609 before the Special Committee on Space and Astronautics, U.S. Senate, 85th Cong., 2d sess., pt. 1, May 1958, p. 91.

House committee proposed in its bill the formation of a liaison committee which would be an arm of the Defense Department much like the Military Liaison Committee created by the Atomic Energy Act. When this idea was raised during the hearings, the reaction of the Defense Department was negative. To Defense witnesses the proposal would create a body which, they feared, would sit over both DOD and the new agency rather than acting as a coordinating instrument.

Even the need for coordination was not particularly appreciated by the Department. Dr. York, in referring to the proposed new Agency, said:³⁹

If their purpose is primarily to explore space and planets and so on, all we need is the information they get. If they are not getting the information that is necessary for defense, we get it for ourselves. That is why I think these things can be almost independent.

This remark indicated a rather naive hope that both agencies could conduct essentially separate activities without expensive duplication.

Since the committee persisted in its search for a coordinating mechanism, the Defense representatives offered the idea of having this role performed directly by the President, or, alternatively, by his scientific adviser, Dr. Killian. The House ultimately rejected this method on the ground that the President's office was already overburdened with duties. The President, in the view of the House, would not have the time for serious consideration of the detailed jurisdictional problems that would arise. Adopting in its bill the recommendation for a Military Liaison Committee, the House group did state that if this body could not resolve a particular dispute to the satisfaction of both agencies, the Secretary of Defense or the head of the new Agency could then refer the problem to the President.⁴⁰

Although the House bill, H.R. 12575, as reported out, went farther in the area of coordination than the Defense Department considered necessary, it did not go far enough in satisfying the demands of the Department that there be a specific declaration that space activities involving military needs should be the exclusive province of the Department.

What the House bill finally did was to give both agencies rather broad jurisdiction in recognition of the large grey area between known military and civilian needs. In so doing, the House bill allowed both agencies to pursue space activities of potential military application. For the Defense Department, the House bill added to the declaration of purpose a broader definition of military activities which included "research and development necessary for the defense of the United States." At the same time it was made mandatory (rather than permissive, as in the administration bill) for the new Agency to cooperate with the Defense Department in this broadened field of activities.

³⁹ Hearings on H.R. 11881, April-May 1958, p. 1539.

⁴⁰ Report of the Select Committee on Astronautics and Space Exploration on H.R. 12575, U.S. House of Representatives, H. Rept. No. 1770, 85th Cong., 2d sess., May 24, 1958, p. 16.

THE ATOMIC ENERGY ANALOGY

These reformulations did not do much to clarify the interagency relationships. Although the House bill deleted the phrase authorizing the new agency to act on behalf of the military, in section 203 it specifically gave the agency authority to pursue military projects by establishing a Division of Military Applications. As in the case of the Military Liaison Committee, the House group was relying on the precedent of the Atomic Energy Commission. In its report on H.R. 12575, the committee said the Division would operate in a fashion similar to its AEC counterpart, which had been assigned responsibility "for all research, development, production, custody, storage, readiness assurance, and testing in the field of atomic weapons."⁴¹

How close a parallel to the AEC did the House Select Committee draw? If the AEC analogy of a Military Applications Division were carried to its logical extent, conceivably the new space agency, and not DOD, would act exclusively in developing military space projects.

A study of the House bill and the accompanying report, however, does not bear out such an extreme position. For instance, the committee stated its primary intentions with respect to military-civilian agency relations on page 7 of the report, where the following requirements were laid down:⁴²

- (a) Cooperation between civilian and military organizations on all matters extending beyond purely peaceful applications or readily identifiable military requirements; and
- (b) Freedom for the military departments to conduct such basic and applied research and development as may be necessary and appropriate to their military missions.

These principles seemed to vest in the new civilian agency authority to do work independently of the DOD in the so-called grey area but not on projects with definite military requirements. In addition, the committee considered that even as to the latter category there would be joint projects and close coordination.

The suggested parallel with the AEC, illustrated by the proposed establishment of a Military Applications Division, was rejected in the law which finally passed, but the suggestion has been revived from time to time in the succeeding years. Consequently, it is pertinent to consider the AEC arrangement in order to see whether it offers a useful analogy.

First of all, the Division of Military Applications within the Atomic Energy Commission is to some extent a misnomer since the Division is almost exclusively a weapons branch which is in charge of the development and production of nuclear weapons. Other projects of military applicability, such as the SNAP power sources and the Pluto nuclear missile, have been conducted by other divisions of the AEC.

Specifically as to nuclear weapons, the Military Applications Division has worked as a support agency for the Defense Department.

⁴¹ *Id.*, p. 14.

⁴² *Id.*, p. 7.

It does not formulate the requirements. These come from the Defense Department. Two facts taken together—namely (1) that the Division is charged only with the task of developing weapons, and (2) that firm requirements are transmitted by the Defense Department—mean that responsibilities and jurisdictional boundaries have been reasonably clear and definitive throughout the history of the Division.

With space projects the situation is markedly different. The list of space projects in which the Defense Department has been interested is a large one, not confined to a single area such as nuclear weapons. In some space projects, military and civilian interests have been pursued simultaneously, as in the case of communications satellites. For these projects, requirements have not been formulated to the degree they have been in the area of nuclear weapons.

Indeed, the biggest difficulty has been that space requirements have not been known precisely in advance. In some instances they have been identified or refined as development or research has proceeded. For this very reason, the Defense Department is compelled to engage in fundamental exploration of space technology and phenomena in order to discover if some defense jobs can be done better in space. There has been an overlap or grey area between the two agencies. As was said in a staff study of the House Select Committee, "The line * * * is much more difficult to draw than is the case with atomic energy."⁴³

RESOLVING THE LEGISLATIVE ISSUES

The Senate special committee accepted the concept of a strong civilian space agency embodied in the House bill, as well as the concept of broad jurisdiction in space for both the civilian and military agencies. The House bill, though unclear as to jurisdictional boundaries, had amended the administration proposal so as to avoid rigid theoretical approaches to the question of division of labor. Rather than identifying in advance the nature of military and civilian space activities or separating research from applications, the House committee had given each agency wide-ranging authority in the space field, leaving to the executive branch the practical chore of assigning projects on a case-by-case method. In so doing, the House committee recognized that space technology was a comprehensive area that could not easily be split into different civilian and military technologies. This delegation of broad authority to each agency finally was incorporated in the act and exists to this date.

Nevertheless, the Senate committee felt the delegation of power should not go farther than the basic intention and specifically rejected the House proposal for a Military Applications Division since it implied that the new civilian agency could develop military systems. Furthermore, the Senate committee pointed out that other parallels with the creation of the Atomic Energy Commission were out of place. The issue in 1958, in the words of the Senate report, was not, as in 1945, civilian versus military control of technology. Both agencies would be under civilian control.⁴⁴

⁴³ Hearings on H.R. 11881, p. 7.

⁴⁴ Report of Special Committee on Space and Astronautics on S. 3609, U.S. Senate, S. Rept. No. 1701, 85th Cong., 2d sess., June 11, 1958.

The essentiality of civilian control is so clear as to be no longer a point of discussion * * *. The military has a specialized interest in space, not for the motives of preemption, but for the simple reason that military capability in space is necessary for the fulfillment of the missions assigned the services * * *. Your committee believes great mischief could be wrought by delegating to the civilian space agency authority over military weapons systems and military operations in the field.

Senator Johnson followed through with this point during the later floor debate of the bill when he noted that the military already had authority in the area of space and were already operating in that sphere of activities.⁴⁵

To give emphasis to this point as well as to avoid any ambiguities which might at some later time vest exclusive jurisdiction in either agency, the Senate committee tightened up the language in section 2 of the bill. It declared in its bill, S. 3609, as revised, that space activities would be under the control of the civilian agency except that those projects "peculiar to or primarily associated with the development of weapons systems or military operations shall be the responsibility of and shall be directed by the Department of Defense."⁴⁶

The Senate committee next focused on the problem of Government-wide coordination. Throughout the course of Senate deliberation of the measure, members continually expressed their concern lest the direction and coordination of the space effort be removed from those officials who would be responsible for the everyday execution of projects. As a result of this concern, the Senate report stated firmly that the "Board, therefore, must be composed of individuals who bear administrative responsibility for the successful conduct of the aeronautical and space activities of the United States."

This coordinating group, in the Senate version, was called the Space Policy Board, to be composed of the Secretary of Defense, the Director of the new space agency, the Chairman of the Atomic Energy Commission, and one designee of the President representing the interests of other agencies. Under the terms of the Senate bill, the Board would conduct a survey of plans and accomplishments, recommend a comprehensive space program, designate responsibilities, and resolve differences between agencies.

The Space Policy Board, it was later explained on the Senate floor, would have no operational control but would have policymaking power. The new agency, according to section 103(a) of the Senate bill, would "in conformity with the determinations of the Board plan, direct, and conduct aeronautical and space activity," but the responsibility and authority for initiating and directing the civilian or military portions of the national space program clearly were to be in the hands of the officials of the new agency and the Defense Department, not of the Board.

This bill also placed the coordination function on a higher level than did the House version. The Senate in its bill did not include the Liaison Committee proposed by the House. In short, the Senate committee was of the opinion that both the Liaison Committee and the Advisory Committee, proposed by the House in place of the Board

⁴⁵ Congressional Record, June 17, 1958, p. 10235.

⁴⁶ S. 3609, as amended: see Congressional Record, June 16, 1958, p. 11289.

in the administration bill, would rely unduly on staff or advisory levels within the new agency and thus would not have effective decision-making powers to achieve complete coordination of all the agencies involved in space activities.⁴⁷

When the individual labors of the House of Representatives and the Senate had been completed, there were obvious differences to resolve. The House bill, H.R. 12575, had passed that body by voice vote on June 2, 1958, and the Senate adopted its version, S. 3609, as revised, by the same procedure on June 16. The Senate insisted on its amendments and asked for a conference.

The conferees retained much of the language of the Senate version regarding basic jurisdiction but also incorporated wording to insure that the Defense Department had authority not only to develop systems but also to pursue any kind of space research and development which was "necessary to make effective provision for the defense of the United States."⁴⁸

This was a significant addition. The administration initially had resisted overly broad language lest the authority of the fledgling space agency be undermined and excessive duplication be encouraged. The Defense Department, on the other hand, objected to language which would confine its scope of activities too narrowly. Without explicit authority for general research and development, Defense representatives feared that future jurisdictional questions might be resolved on a too literal interpretation of the phrase "peculiar to or primarily associated with the development of weapons systems, military operations or the defense of the United States." Such an interpretation might restrict the Defense Department to building only hardware to meet a specific military requirement. The final language of the act made it abundantly clear that the military were not confined to applications and systems meeting hard-core military requirements but could also engage in broad research and development to accomplish the defense mission. The identification of appropriate tasks within each jurisdictional sphere would be left to the agencies concerned, with the President acting as arbiter and judge in case of conflict.

THE MEANING OF "PEACEFUL PURPOSES"

At the same time, the emphasis clearly was put on peaceful purposes of all U.S. space endeavors. Such emphasis was not meant to equate "peaceful" with "civilian" nor "peaceful" with "nonmilitary." The declaration of purpose as finally enacted read, as follows:⁴⁹

SEC. 102. (a) The Congress hereby declares that it is the policy of the United States that activities in space should be devoted to peaceful purposes for the benefit of all mankind.

(b) The Congress declares that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities. The Congress further declares that such activities shall be the responsibility of, and shall be directed by, a civilian agency exercising control over aeronautical and space activities sponsored by

⁴⁷ Final report of the Special Committee on Space and Aeronautics, U.S. Senate, S. Rept. No. 100, 96th Cong., 1st sess., Mar. 11, 1959, p. 7.

⁴⁸ Conference report on H. R. 12575, H. Rept. No. 2166, 85th Cong., 2d sess., July 15, 1958.

⁴⁹ National Aeronautics and Space Act of 1958, Public Law 85-568, 72 Stat. 426; for act as amended see 42 U.S.C. 2451.

the United States, except that activities peculiar to or primarily associated with the development of weapons systems, military operations, or the defense of the United States (including the research and development necessary to make effective provision for the defense of the United States) shall be the responsibility of, and shall be directed by, the Department of Defense; and that determination as to which agency has responsibility for and direction of any such activity shall be made by the President in conformity with section 201(e).

If the legislative intention conveyed by the expression "peaceful purposes" is somewhat vague, the substantive language of the act in subsection (b) of section 102 declares explicitly that the military shall conduct operations and research and development in the space regime. Consequently, it is impossible to contend that Congress forbade military space activities when it declared it was U.S. policy that "activities in space should be devoted to peaceful purposes." Congress also did not state that only NASA work would be peaceful.

If any doubts remain about legislative intentions, it is helpful to note a resolution on the peaceful exploration of space passed by the same session of Congress which enacted the National Aeronautics and Space Act. The resolution, originally proposed by Mr. McCormack,⁵⁰ expressed the sense of Congress that the "United States should strive, through the United Nations or such other means as may be most appropriate, an international agreement banning the use of outer space for military purposes."⁵¹ This resolution did not state a present policy of banning the use of space but instead expressed a desire for a future international disarmament agreement.

If the Space Act does reflect the hopes of many for an international disarmament agreement governing outer space, such hopes ought not to be confused with statements of fact. Unfortunately confusion has prevailed in the years since the passage of the act. Despite repeated attempts on the part of high officials in the Government to explain the military role in space, there is much doubt often expressed about the propriety of military participation in space work. Adding to this doubt are unintentional inaccuracies of expression which allocate "peaceful" work to NASA, implying "nonpeaceful" military work on the part of the Defense Department. Such a characterization would logically but incorrectly place all Defense Department activities in the "nonpeaceful" category. Unless involved in actual fighting or otherwise belligerent or aggressive military space activities are peaceful in the sense that they are devoted to keeping the peace. Military vehicles can operate in space, as military vessels do on the oceans, without being warlike.

To resolve the potential conflicts in the "grey area," the conference reported that machinery was necessary at the highest level of the government. The machinery established was a compromise which accommodated both the House and Senate viewpoints as well as that of the administration. Essentially, the job of coordination was given to two bodies: (1) The National Aeronautics and Space Council, composed of the President, the Secretaries of State and Defense, the

⁵⁰ H. Con. Res. 326, 85th Cong., 2d sess.

⁵¹ H. Con. Res. 332; see S. Rept. No. 100, 1959, pp. 15-21.

Administrator of the new space agency, the Chairman of the AEC, one other governmental representative, and three nongovernmental representatives; (2) the Civilian-Military Liaison Committee, made up of an equal number of representatives of the new agency and the military departments. In the original House version the second body would have been composed only of military representatives.

The task of the Liaison Committee was to strive for agreement between the agencies. Only if agreement could not be reached satisfactorily at that level would the dispute go to the President, who would then act under his authority as Chairman of the Space Council. The job of the Council was to advise the President with respect to his duties under the Space Act, which included, among others, the designation of agency responsibilities, effecting coordination among the various agencies, and the resolution of differences regarding space activities. The Council also was tasked with advising the President in developing a comprehensive program of space activities.

Such top level direction would not stand in the way of a vigorously prosecuted space program run by agencies which had both authority and responsibility. The act's principal function was to establish a new space agency, vastly different from the old NACA. The new agency, to be called the National Aeronautics and Space Administration, was no longer to be removed from the attention and policy control of the President, nor was it to be dependent on the military. Its Administrator and Deputy Administrator were to be appointed from civilian life by the President with the advice and consent of the Senate. The old NACA had picked both its Chairman and its Director without the exercise of either Presidential or congressional power.

By section 203(a) the new Administration was directed to "plan, direct, and conduct aeronautical and space activities." The agency was given the authority to hire without regard to the civil service laws, although this authority was limited to hiring a maximum of 260 persons in contrast to the unlimited number originally requested. In addition, the agency could establish the entrance grade for personnel without previous Federal service at a level two grades higher than ordinarily required.

The agency also was given the authority to acquire facilities, contract, buy and sell property interests, use the resources of other agencies with their consent, and employ retired or active military personnel. The authority to acquire by transfer other Government agency functions also was granted, but again with limitations. This power would reside in the President for a period of four years but would be subject to congressional approval after December 31, 1958.

The conference bill passed both Houses of Congress on July 16, 1958, and the President signed it into law on July 29. On September 30, NACA ceased to exist and the following morning the new space agency, NASA, began operations.

IV. THE SEARCH FOR A NATIONAL SPACE PROGRAM: 1958-60

NASA BEGINNINGS

When the new space agency began business, almost a year had passed since Sputnik had inaugurated the space age. Despite the impressive headstart of the Soviets, the United States, with the passage of the National Aeronautics and Space Act of 1958, had committed itself to nothing less than world leadership in space activities. Achievement of this goal was specifically required in section 102(c)(5) of the act. The Congress had declared that both the general welfare and the security of the country demanded a comprehensive national program to achieve this goal.

The Congress had prescribed a national space program but had insisted on a duality of functions, military and civil, and the participation of several agencies. The job of fitting together the many pieces to form a consistent, coordinated, and efficient national program now was left in the hands of the Executive. By October 1, 1958, the resources for space development available to the Executive were significantly larger and stronger than those in existence a year earlier.

Obligational authority of almost \$800 million in fiscal year 1959 was at the disposal of the space program, a figure at least eight times greater than that specifically directed to space purposes before Sputnik. This large sum was distributed among several agencies. ARPA had \$331,726,000 in military space technology projects. NASA had \$384,073,532, consisting of \$80 million in direct appropriations to the new agency, \$101 million in NACA funds, \$154.6 million in transfers from the Defense Department, and supplementals. The remaining amount was found in the military service budgets and in the Atomic Energy Commission.⁵²

Inheriting the 7,000-person complement of the old NACA together with its field stations and laboratories, NASA also received by virtue of an Executive order, signed on the same day the new agency came into existence, several Defense projects and their personnel, including the Vanguard satellite, the lunar probe, and the large single chamber rocket engine.

To direct the activities of the new agency, the President chose a highly competent, experienced team. Appointed as Administrator of NASA was Dr. T. Keith Glennan, president of Case Institute of Technology in Cleveland, Ohio. Dr. Glennan had served as the head of the Navy Underwater Sound Laboratories during the war and as a member of the Atomic Energy Commission from 1950 to 1952. Dr. Hugh Dryden, Director of the National Advisory Committee for Aeronautics, was named Deputy Administrator. Renowned in his

⁵² See report to the Congress, "U.S. Aeronautics and Space Activities, 1964," Appendix E-1: for ARPA funding see "DOD Appropriations for 1960," hearings before the Subcommittee of the Committee on Appropriations, U.S. House of Representatives, pt. 6, 86th Cong., 1st sess., p. 93; for NASA funding see "S. Rept. No. 100," 1959, p. 52. Unless otherwise noted, the source for historical funding information used in the report is found in appendix A, p. 121.

own right as a scientist, Dr. Dryden had a record of long and distinguished Government service during which he had made important contributions to the technology of flight.

These appointments represented a blend of the old and the new, necessary if NASA was to meet the challenges of the Space Act while at the same time maintaining the solid foundation of experience gained during the existence of NACA. These two men immediately turned their attention and skills to the task of organizing the expanded space effort.

One of Dr. Dryden's main objectives was to insure that the old NACA facilities, such as the Ames, Lewis, and Langley Laboratories, were kept intact in order that they might continue working on their tasks of directed research. These activities were given coequal but separate status with the new or expanded space flight activities.

TRANSFER OF MILITARY RESOURCES

The new agency also relied on NACA experience in organizing space flight activities. Dr. Abe Silverstein, associate director of the Lewis Laboratory, was brought to Washington to organize the space flight development program. The NACA resources in this area were small; hence new centers had to be created. In part, NASA relied on transfers of facilities and personnel to accomplish this task. That part of the Naval Research Laboratory work associated with Vanguard and upper atmosphere research was transferred to a new center at Beltsville, Md., later to become the Goddard Space Flight Center. By another Executive order, issued in December 1958, NASA acquired the Jet Propulsion Laboratory, associated with the California Institute of Technology. JPL had been operating as a nonprofit contractor organization for the Army and was engaged in work on tactical field missiles such as the Corporal and Sergeant. The Laboratory continued its semi-independent status, working now for NASA. The Air Force transferred to NASA its contract and funds to develop a million and a half pound thrust single chamber engine. By these moves NASA quickly gained competence in electronics, guidance, tracking, propulsion, and systems analysis. In short, NASA was on its way to becoming a big systems developer like the Defense Department.

NASA actually wanted more than JPL from the Army and had requested transfer of a portion of the Army Ballistic Missile Agency at Huntsville, Ala. Such a transfer would give the new agency a talented group for space systems design and engineering, in-house resources for hardware work, and an organization experienced in dealing with industrial contractors. Prior NACA launching experience had been confined to the small station at Wallops Island.

The Army opposed the transfer, having determined that the ABMA group was necessary for the accomplishment of missile projects. Similar considerations had been voiced with respect to JPL. A temporary accommodation was achieved by a cooperative agreement between the Army and NASA, signed on December 3, 1958.

With respect to the JPL transfer, the Army maintained its contractual relations to complete work on the Sergeant and other programs. As for the ABMA at Huntsville, the Army retained full supervision and control but agreed to make the resources available

to NASA upon specific project request. Such work was to be the full responsibility, however, of the Army and conducted so as not to interfere with military projects.

This arrangement was disappointing to NASA, which publicly stated that future negotiations would be conducted in the following year if the arrangement proved inadequate to its needs.⁵³ This set the stage for a rather lengthy struggle suggesting that civil-military relations in the space age would not be altogether harmonious.

In the meantime NASA proceeded to set its own house in order. By the end of January 1959 the first organizational pattern was formally established.⁵⁴ The theme was decentralization. Although the Administrator and his Deputy had an immediate staff of legal counsel, program planners, and liaison officers for outside and interagency contracts, the execution of the programs was left to the centers and to the two program offices at headquarters to whom the centers reported. Instead of an overall facility coordinator and financial comptroller at the top echelon, there was a separate office of business administration at the same level as the two program offices but distinct from them. This reflected the philosophy of a research organization which feared a too tight money control that would inhibit investigation and innovation.

One of the program offices was in charge of aeronautical and space research. The Langley, Ames, Lewis, and Edwards high-speed flight centers reported to this office. The other office was responsible for space flight development and included directorates for advanced technology, propulsion, space science and flight operations. Reporting to this office were the Wallops Station, the new Beltsville Space Center, and the Jet Propulsion Laboratory.

Having organized itself, NASA had next to decide which projects it would pursue. The previous emphasis of the National Advisory Committee for Aeronautics on laboratory tests and research would no longer suffice. To explore space would require laboratories in space itself. This meant big systems. At first, however, the transition was quite gradual, and the bulk of the fiscal year 1959 funds were still being spent at centers which were oriented to areas of scientific concern rather than to applications and systems.⁵⁵ The organization and structure formed in January 1959 also contributed to this orientation.

The Defense Department, on the other hand, where systems work and project orientation had been the rule, continued to push big projects with funds much larger than those of the new Agency. And still more projects were coming off the drawing boards.

ARPA and Air Force work was in part related to missile activities, such as that involving solid propellants, launch facilities, and test ranges. Other work combined both space and missile activities, including antisatellite identification and defense and the missile early warning satellite, Midas. Beyond this the list of 1958 military space projects was impressive: orbital gliders, new boosters and satellites for reconnaissance, communications, weather forecasting, and navigation. In December 1958 the Discoverer program was begun to develop hardware and techniques for stabilizing spacecraft, returning satellites to preselected points on the earth, and recovering data from

⁵³ NASA Supplemental Authorization for Fiscal Year 1959, hearings on S. 1096 before the Committee on Aeronautical and Space Sciences, U.S. Senate, 86th Cong., 1st sess., Feb. 19, 20, 1959, p. 10.

⁵⁴ See NASA organization charts in appendix B, faces p. 122.

⁵⁵ S. Rept. No. 332, 86th Cong., 1st sess., June 2, 1959.

satellites. In the planning and study stage were manned satellites and space stations.

Early Defense predominance in space activities was furthered by NASA itself, which used either ARPA or the military services as executive agents to accomplish projects already transferred to the new agency. In addition to its own space launches, the Department of Defense performed the actual work on five of the eight NASA-directed shots in fiscal year 1959. The Air Force handled the first two Pioneer space probes. The Army launched Pioneers III and IV and also conducted the Beacon shot, an unsuccessful attempt to use an inflatable satellite for testing atmospheric densities.

ATTEMPTS TO SET A DIVISION OF LABOR

While still in its infancy, it was natural for NASA to depend on the military and its wealth of experience and facilities. Gradually this dependence would be reduced, but in the meantime the NACA experience continued to motivate the new agency.

For instance, the new agency at first indicated willingness to handle the man-in-space project as a joint one with the military. It took the Budget Bureau to steer NASA away from this track. Nevertheless, the project was later dubbed a cooperative one, despite the decision to transfer ARPA funds and project responsibility to NASA.

The Defense Department recognized that a more radical shift was possible and attempted to establish a rough division of labor. In March of 1959, Roy Johnson, the Director of ARPA, stated that military space efforts would be limited to 600 miles above the earth.⁴⁶ This suggested a division of responsibilities whereby NASA would work in outer space and DOD in inner space.

Since ARPA was even then studying a synchronous-orbit communications satellite for operations at an altitude of 22,000 miles, this demarcation seemed inaccurate. Conversely, the Mercury-manned satellite project, funded by NASA, was planned for operating substantially below this 600-mile limit.

The real intention behind Johnson's statement, as he tried to explain at a later Senate hearing, was to point out that the military were not interested in exploring the moon or planets. In the same hearing, however, he went on to argue quite emphatically that the NASA and DOD space activities should be treated separately and not as parts of a comprehensive national space program. The divergence between the two agencies, he said, would further widen, implying that NASA would concentrate on scientific space exploration and DOD on military applications. Specifically, he said that the NASA Mercury man in space project was a continuation of NASA projects like the X series aircraft, but that after early experiments, the military would do the follow-on work in near-earth space systems. Finally, Johnson indicated that the two agencies' work was so different and separate that there would be little problem in coordination or duplication.⁴⁷

Other Government officials also insisted there was a clear separation between the work of the two agencies. For instance, in a speech

delivered in late 1959, the General Counsel of NASA rejected the notion of a space program and instead referred to a "space exploration program" which was solely NASA's responsibility and did not embrace military uses. This attitude was a carryover from the original legislative proposals of the Administration. Congress, however, by the Space Act of 1958 had specified a comprehensive national space program and had rejected the idea that space technology could be separated easily.

The initial compartmentalization of space was furthered by the statements accompanying the announcement made in late 1959 that the Von Braun team at Huntsville would be transferred to NASA. The President's press secretary said that the effect of the move was "to take the Army out of the field of space exploration."⁴⁸ In this context space exploration obviously included big booster development, for with the transfer of Army resources went the Saturn project for developing a powerful new rocket of 1.5 million pounds of thrust.

The Army resisted this transfer, but it would be inaccurate to attribute this resistance only to Army ambitions in the area of space exploration. The Saturn project was an outgrowth of the Army missile program, and the booster was being developed as a cluster of eight engines such as those used in the Army's Jupiter. There was concern also that the Von Braun team would not be kept intact at Huntsville but dispersed to the far corners of the new space organization. These fears did not materialize.

An earlier reorganization of the military space program had implied that the Air Force would get the Saturn project. In September 1959 the Air Force was given sole responsibility for the development, production, and operation of all military space boosters. Therefore, the real question raised by the President's proposal to transfer the Saturn and the Von Braun team to NASA was whether the military would be barred henceforth from developing big boosters.

In a press conference on October 22, 1959 President Eisenhower indicated that the big booster had "its primary place in space exploration and not in our missile program."⁴⁹

It was open to question whether the transfer of the Von Braun team to NASA indicated that a principle had been established with respect to the division of space labors. For the time being it could be said that Saturn had suffered from a lack of a firm military requirement. Although it had been considered at one time for launching a synchronous communications satellite, smaller rockets obviously could do that job.

REASSIGNMENT OF MILITARY SPACE FUNCTIONS

There seemed to be developing a further scattering rather than a consolidation of space tasks. Barely a year after ARPA's inception, steps were taken which forecast its decline. Even while it was pushing ahead vigorously with a vast array of projects, ARPA's unique status as a centralized military space agency began to erode. At first this was due to an inevitable clash with the new Directorate of Defense Research and Engineering (DDR&E), created as a result of the 1958 reorganization of the Department of Defense. Since the new organi-

⁴⁶ New York Times, Mar. 11, 1959, p. 1.

⁴⁷ Hearings on Investigation of Governmental Organization for Space Activities before the Subcommittee on Governmental Organization of the Committee on Aeronautical and Space Sciences, U.S. Senate, 86th Cong., 1st sess., 1959, pp. 107-185.

⁴⁸ New York Times, Oct. 22, 1959, p. 1.

⁴⁹ New York Times, Oct. 23, 1959, p. 1.

zation was given formal authority over all Defense research and development, it was inevitable that ARPA, which had the privilege of direct access to both the military services and the Secretary of Defense, would clash with DDR&E. During the early stages, when the new organization had to build up a staff and learn how to exercise its authority, ARPA was able to continue in its own vast field. By early 1959, however, the charter of the Directorate of Defense Research and Engineering was clearly set forth. Secretary of Defense McElroy gave its Director, Dr. Herbert York, the authority to "approve, modify, or disapprove programs and projects of the military departments and other DOD agencies."⁶⁰ This authority gave Dr. York the ability to cancel unpromising or duplicate programs and to initiate or support promising ones. ARPA logically would be subject to this power, but not until later in the year was the change officially ordered which made ARPA answerable to DDR&E rather than directly to the Secretary of Defense.

A directive issued on December 30, 1959, established ARPA as "an operating research and development agency of the Department of Defense under the direction and supervision of the Director of Defense Research and Engineering." This directive gave DDR&E even more control over ARPA than over the military services.⁶¹ In effect, ARPA became a line agency under the management control and supervision of the Director of Defense Research and Engineering.

In the fall of the year ARPA also lost many of its space projects, notably Midas, the satellite for early warning against ballistic missiles, transferred to the Air Force; Samos, a reconnaissance satellite project, also to the Air Force; Transit, the navigation satellite, to the Navy; and Notus, the interim communications satellite system, to the Army. This was in keeping with a policy statement announced at the same time that ARPA control was only for advanced systems and that it had always been the expressed intention of the Department to shift projects to the services when development was far enough along to indicate eventual operational use.⁶²

Events proved that some of these projects were still far from operational use. Furthermore, the indications were that even for research and development, space projects would be more within the province of the services than of ARPA. For instance, Dr. York at a press conference stated that the Air Force would henceforth develop all space boosters needed by the Department of Defense.

The transfers carried mixed blessings. They pleased military service representatives who had traditionally argued that development should be lodged with the user agency. Roles and functions of the services also were strengthened by the move. On the other hand, taking space from the spotlight of centralized Defense management close to the Secretary of Defense could result in a diminution of interest in Defense space activities. Of more immediate significance was the fact that now space projects would have to justify their existence along with a host of other service projects and expenditures. This forecast the possibility of budget cuts both at the service level and higher.

Another effect of the move soon apparent was an increase in interservice rivalry. Each military service was on the same footing in

⁶⁰ Hearings on Governmental Organization for Space, U.S. Senate, cited *supra*, p. 550.

⁶¹ DOD Directive No. 5129.33, Dec. 30, 1959.

⁶² DOD Press Release No. 1087-59, Sept. 23, 1959.

making claims for space projects. Many of the projects, particularly satellites, were technologically related and did not conform readily to traditional service roles and missions. For instance, each service had communications systems and therefore corresponding claims on a satellite communications project. In some cases, the problem of assigning space projects was much like the missile controversy. Although the Air Force was assigned Midas, the ballistic missile early warning satellite, the Army also had claims on air defense. The increased rivalry led the Navy to advocate a unified space and missile command.⁶³

This similarity of projects, at least technologically, was also at the root of the more prominent interservice struggle in the field of missile weapons systems. All of the military services had such weapons in development. Both the Army and the Air Force had land-based intermediate range missiles, the Jupiter and the Thor. The Navy had its sea-based missile development, the Polaris. Both the Army and the Air Force laid claims to the air defense missile field, the Army with its Nike series and the Air Force with its Bomarc system.

The struggle over rocket weaponry predated Sputnik and the space age and persisted after the governmental reorganizations of 1958. Despite the new powers given to the Secretary of Defense by the Reorganization Act of 1958, particularly the creation of the office of the Director of Defense Research and Engineering, the Department by 1959 was still unable to resolve the conflicts within its organization. Almost in desperation, the Secretary turned to Congress for help in making the necessary project and mission decisions. When Secretary McElroy appeared before the Senate Defense Appropriations Subcommittee on May 4, 1959, he admitted that in the fight between competing air defense systems, he had been unable to make the decision himself. Thus prompted, the subcommittee chairman, Senator John Stennis, suggested to the Secretary that perhaps he would welcome a congressional decision on this matter. Secretary McElroy replied:⁶⁴

As far as I am concerned, it would not bother me if you held our feet to the fire and forced us * * *.

CIVIL-MILITARY JURISDICTIONAL CONCEPTS AND REALITIES

The ARPA divestiture also involved NASA, blurring jurisdictional lines between military and civilian responsibilities as well as those within the Department of Defense. Among the projects transferred to NASA were Tiros, the weather satellite, and Centaur, the high-energy upper stage. Although these transfers supposedly were in the interest of consolidating nonmilitary space projects under one roof, the projects continued to have military requirements. The Tiros was needed for operational forecasting by the military forces, and Centaur was slated for use as a launch vehicle for the military communications satellite.

Other applications projects begun in 1959 by NASA indicated that the new agency was not going to confine itself either to directed research or scientific space exploration. It announced the start of a passive communications satellite project, Echo; and a geodetic satellite

⁶³ New York Times, Sept. 25, 1959.

⁶⁴ "DOD Appropriations for 1960," hearings before the subcommittee of the Committee on Appropriations, U.S. Senate, 86th Cong., 1st sess., 1959, p. 33.

for mapping and other geophysical purposes. Again, the military needs and benefits were apparent. In fact the services were pursuing parallel work in both fields.

By the same token, Defense was not confining itself to systems or applications projects since it was engaged in research work in propulsion, biosciences, solar radiation, and advanced energy conversion.

A beneficial result of the jurisdictional overlap was that the two agencies were forced to work together more closely. Each agency was learning to look to the other for help and assistance. This involved more than an exchange of information on related projects. NASA supported the Dyna-Soar recoverable orbital glider project of the Air Force by carrying out various design and research activities in its laboratories and wind tunnels. In turn, the DOD provided launch, range, and ground-station support to NASA space vehicle programs. Personnel also were provided. In late 1959, an Air Force general became head of the new NASA office for launch vehicle programs. The Mercury astronauts also were selected from the military services.

Regardless of this measure of cooperation, the Government's space program to many observers began to seem increasingly confused and disjointed. In Congress, the argument often was made in 1960 that the Administration had no overall space program and no definite goals. Congress was particularly sensitive to the matter of program planning because it had seen its specific legislative provisions for unified control and direction go somewhat unheeded in the Executive.

After 2 years, the National Aeronautics and Space Council, created by the Space Act of 1958, showed few signs of life. No full time staff or Executive Secretary was appointed despite provisions made for them in the act. The act had directed the Space Council to formulate a comprehensive, integrated space program for the Government, but this too was not forthcoming.

There were similar failures in the coordination mechanisms required by the Space Act. The Civilian-Military Liaison Committee was not helped by delays in appointing its membership. Some of the officials selected were not directly associated with the management of space projects. Its first Chairman, W. M. Holaday, also served as Director of the Guided Missiles Committee in the Pentagon. The Civilian-Military Liaison Committee showed no decisive impact on the course of events.

In July 1959 the President had to revise the charter of the Liaison Committee so that it would take the initiative in dealing with jurisdictional differences between NASA and DOD. Before this change, the group considered that it could handle such problems only when requested to do so by the agencies. But this addition did not alter the situation very much. Chairman Holaday himself called the Committee "nothing more than a post office," when he appeared in 1959 before a Senate committee investigating the Government organization of space activities.⁶⁴ The Administration made its position completely clear the following year when it formally requested Congress to dissolve the Liaison Committee. Administration spokesmen argued that "the civilian and military functions in space development are separate responsibilities requiring no coordinating body."⁶⁵

⁶⁴ Hearings on Governmental Organization for Space, U.S. Senate, cited *supra*, p. 504.

⁶⁵ New York Times, Apr. 15, 1960, p. 3.

This position was in flat disagreement with the concept of civil-military relationships embodied in the act and harked back to the Administration's original disposition in 1958 to compartmentalize military and civilian activities. Disagreeing with certain provisions of the act as he did, the President had no choice but to seek amendments to it. This he did on January 14, 1960.

In frank language, President Eisenhower declared in his message⁶⁷ to the Congress that the act as it stood embodied the concept of a "comprehensive program" of space activities which he considered incorrect. Accordingly, the President asked for "elimination of those provisions which reflect the concept of a single program embracing military as well as nonmilitary space activities." Referring to the experience of the space age to date, the President asserted that:

In actual practice, a single civil-military program does not exist and is in fact unattainable; and the statutory concept of such a program has caused confusion.

Seeing no prospect for a comprehensive and integrated national space program, President Eisenhower did not need a Space Council, which he asked be abolished along with the statutory responsibility of the President and the Council to formulate a comprehensive program.

DEMANDS FOR SPACE PLANNING

Recognizing that these steps would not satisfy the congressional demand for program planning, at least on the part of each agency, NASA put forward during its budget presentation in early 1960 a "10-year plan."⁶⁸ The name was somewhat misleading since it was soon being explained as merely a launch program estimate. It did not purport to fix deadlines but was instead a guideline for further planning. Even so, the schedule was a mixture of optimism and caution. For instance, it called for a successful Mercury shot as well as a Centaur launch in fiscal year 1961. It turned out that Mercury was not successful until calendar year 1962. Centaur had its first success on November 27, 1963. The plan also estimated an unmanned soft lunar landing in fiscal year 1963. This has yet to be realized.

On the conservative side, manned flight to the moon was not included at all within the planning period of 1960 to 1970. A comment added to the schedule indicated that manned lunar flight could take place sometime after fiscal year 1970. The cost estimate for this modest program was set at \$13 to \$15 billion over the 10-year planning period. As projected by this estimate, the annual pace was never higher than \$2 billion.

Congress was not satisfied. The House Science and Astronautics Committee issued a report in July 1960 which called for fixing as a definite goal a manned lunar expedition within the decade. In support of this goal, the committee urged a faster schedule and higher priority for the F-1 large single-chamber rocket engine which was then lacking any definite assignment but which would be needed for a moon project.⁶⁹

Congress rejected the President's request for amendments to the Space Act. Instead, the Administration had to bow to congressional

⁶⁷ Congressional Record, Jan. 14, 1960, p. 663.

⁶⁸ S. Rept. No. 1300, 86th Cong., 2d sess., pp. 77-78.

⁶⁹ "Space, Missiles, and the Nation," H. Rept. No. 2092, 86th Cong., 2d sess., p. 55.

demands for greater coordination. Although it allowed the Liaison Committee to become defunct, it created in its place a potentially more effective body, the Aeronautics and Astronautics Coordinating Board. This was a formal body for coordination composed of officials with actual administrative or policy responsibility for space activities. The two Co-Chairmen initially were the Deputy Administrator of NASA, Dr. Dryden, and the Director of Defense Research and Engineering, Dr. York. The remaining members of the Board also were officials directly connected with the day-to-day management of space projects in the two agencies. The Board was organized along functional lines, recognizing the similarity of the two agencies' needs and projects, with six panels corresponding to major areas of work such as launch vehicles, applications, support, and advanced research.

The duties of the Board were to plan, review, and define space programs and project support. Furthermore, the Board was charged with making adjustments to programs when necessary to eliminate unwanted duplication.

These moves did not still the voices of criticism which continued to be heard in Congress and in the country at large. A mood of uneasiness about American space activities began to settle over the Nation. As usual throughout the brief but stormy history of the space age, the spate of criticism coincided with new Soviet successes. The pace of spectacular Soviet achievements followed one upon the other after the original sputnik. In the Soviet Lunik program, the Russians first hit the moon on September 13, 1959 and then photographed its far side on October 18 of the same year. In August 1960 the Russians succeeded in recovering a 5-ton satellite containing two dogs, which was obviously developed for eventual manned flight. Inevitably, these events were contrasted unfavorably with the American effort.

Although the Russians undoubtedly seemed far ahead of the United States, the achievements of the American program by the end of 1960 were pushed to one side by the public. In proper perspective the American efforts in 1960 were not insignificant. A wide range of practical space operations was proved feasible during that year by the following successful launches: the Tiros weather satellite on April 1; the navigational satellite, Transit 1-B on April 13; the Midas missile detection satellite on May 24; the passive communications satellite, Echo 1, on August 12; and the active communications satellite, Courier, on October 4. Tiros and Echo were NASA projects; Transit, Midas and Courier were DOD projects.

Since these shots were all development launches and not yet working systems, they only pointed to, rather than assured, a better future for the American space effort. In space sciences the United States was making great strides. For example, in March 1960 [the NASA Pioneer V was placed in a solar orbit between the earth and the planet Venus, transmitting data from the record distance of 22.5 million miles, which confirmed the existence of an interplanetary magnetic field and showed that this field varied with solar flare activity. This achievement, like the others, was soon lost from sight in the tumult of a national election campaign in which space and particularly the organization of space activities became a major issue in the debate. The outgoing Administration had decided against a national program, but new decisions were soon to be made.

V. NEW GOALS IN SPACE: 1961-62

PRESIDENTIAL REVIEW OF SPACE ACTIVITIES

By the time the new Administration took office in mid-January 1961, Mr. Kennedy and his advisers had identified what they considered the major problem areas in the space program. Most of their studies revealed one overriding concern: the need for program direction. This concern was heavily emphasized in a major study report made to the President-elect by his ad hoc committee on space, a task force chaired by Dr. Jerome B. Wiesner, who was to become the new President's scientific adviser.

The group concluded that the Nation's space efforts suffered from a lack of definite goals. This was so despite—and to some extent because of—the abundance of projects. Although lagging in the big booster field, which prevented the United States from achieving big space spectacles like those of the Soviets, American discoveries and developments in other fields excelled. American space exploration had resulted in the discovery of the Van Allen radiation belt, greater knowledge about solar flares, and confirmation that space was not empty but contained a tenuous plasma. In technology we had made great progress in instrumentation. Basic work also had been done in applying satellites to uses in communications, geodesy, navigation, observation, weather forecasting, and astronomy. Much of space work, however, had proceeded on a level-of-effort basis. Few definitive schedules had been laid down or clear goals established. Without them neither technology nor research could be vigorously exploited. Without fixed goals it was hard to allocate funds or to generate wide support.

The Wiesner report made no specific recommendations with respect to projects, but it did clear the deck for action by separating the space effort into recognizable, discrete areas: propulsion, space sciences, applications, manned space, and military astronautics.

The committee recommended that each of these areas be given vigorous, centralized management. To pull all the areas together the committee further recommended the revitalization of the Space Council.

President Kennedy immediately accepted the last recommendation. In so doing he promised publicly that the Council would have as one of its first tasks the charting of the Nation's course toward pre-eminence in space. Specifically, this meant he wanted the Council to advise him how the Nation could overtake the lead of the Soviet Union.

To enable the Council to do a more effective job, the new President sought and quickly obtained amendments to the Space Act of 1958.⁷⁰ The role of Chairman of the Space Council was transferred from the President to the Vice President. The President was also freed of the specific duties under the Act of developing a comprehensive space

⁷⁰ Public Law 87-26, 75 Stat. 46. For the Space Act as amended see 42 U.S.C. 2451.

program, assigning agency responsibilities, and coordinating activities. The President did not lose the constitutional authority to make decisions, but the amended Space Act authorized the Council to assist the President, as he may request, in performing these important functions. By these changes the President was given a strong arm in achieving better Government-wide space planning and cooperation. The President further enhanced the job of the Space Council by appointing Dr. Edward C. Welsh to the post of Executive Secretary of the Council, a position which had been vacant since the passage of the Space Act in 1958.

Armed with new resolution and increased staff strength, the President and the Space Council soon were given the opportunity to make good on their promises. On April 12, 1961, Maj. Yuri Gagarin of the Soviet Union became the first man to travel into space when he successfully orbited the earth in his Vostok space capsule weighing over 5 tons.

This impressive feat of the Soviets focused immediate attention on American manned space efforts. The President already had committed himself to a program which would give the United States space superiority. Mercury no longer would suffice for this and, faced with the fact that the Soviets would retain the honors for some time, the Nation had to plan for the longer term.

New manned space flight projects to follow Mercury had been disallowed by the outgoing Administration. President Eisenhower's space budget for fiscal year 1962 had been held down almost to the level of the previous year. If that modest budget level were maintained, the space program would have to continue on a rather cautious, slow basis. When the new President took office, he was not yet ready for major decisions in space, but he did direct that the NASA budget be reviewed. This review resulted in the submission to Congress on March 28, 1961, of an additional \$125.7 million request for NASA fiscal year 1962 funds. This was only a provisional step.

The administration also deferred making big changes in the organization of the space effort. The President's advisers had recommended tightening of the lines of authority and project direction. In both the military and civilian agencies there was a wide dispersal of authority and projects. The military services competed for space projects and contended with top-level Defense management. In NASA there were somewhat similar problems of project and field center autonomy and resistance to headquarters direction. But organizational changes were postponed pending the determination of new goals and new projects.

THE LUNAR LANDING DECISION

The President delegated the job of drafting new goals for the space program to his Vice President, Lyndon Johnson, in his new role as Chairman of the Space Council. The Vice President consulted with leading Congressmen, businessmen, scientists, and top military and NASA officials. The job at hand was devising a specific action program. There were no ready-made blueprints available, but there was a host of ideas and concepts. Although the lunar landing decision that followed has come to be regarded by many as originating in 1961, the idea of such a venture had been considered ever since there was serious talk about space exploration;

A lunar program for the post-1970 period had been listed in NASA's 10-year plan presented in 1960. In that year the agency had contracted for feasibility studies of such a program. These were completed while the Administration deliberated its course of action in early 1961. During this time the Space Science Board of the National Academy of Sciences concluded that "scientific exploration of the moon and planets should be clearly stated as the ultimate objective of the U.S. space program for the foreseeable future."

Everyone recognized the high cost of such a program, but precise estimates were not possible. Some estimates ranged as high as \$40 billion. Clear answers also were missing on the questions of schedules, techniques, and hardware. Nevertheless, the Vice President and his team worked at a fast pace through April and part of May 1961 to formulate a firm proposal.

On May 25, 1961, President Kennedy announced in a special message⁷¹ to Congress the national goal of landing a manned expedition on the moon within the decade. The words of the President were bold and challenging, in keeping with the decision itself:

Now it is time to take longer strides—time for a great new American enterprise—time for this Nation to take a clearly leading role in space achievement which in many ways may hold the key to our future on earth.

Aware of its historic significance, President Kennedy predicted the action would be considered "as among the most important decisions that will be made during my incumbency."⁷² The goal, as the President made plain, was not simply landing a man on the moon within the decade but gaining a broad competence and a preeminent status for American space activities. Other specific major tasks set out by the President in his message included faster development of the Rover nuclear rocket, acceleration of work to provide early communications and weather satellite systems, and the initiation of a new military solid-propellant booster development.

The program launched in May of 1961 soon made space one of America's biggest businesses. It also made space big government. The President accompanied his message with a new budget request for the 1962 fiscal year which was twice the appropriations of the previous year.⁷³ The sum of \$1.8 billion was large, the President told the Congress, but he wanted them to approve the request only if they committed themselves to a vast program covering the entire decade. The new Administrator of NASA, James E. Webb, indicated that the total price tag of the lunar program, called Apollo, would range from \$20 to \$40 billion.

The reaction of Congress was a heavy vote in favor of the lunar landing decision. When final actions on fiscal year 1962 obligatory authority were completed, the Congress had given the President all of the \$1.8 billion he had requested.

The increased funding and the establishment of clear, long-range goals for the American space effort galvanized the various Government agencies into action. The scattered resources and projects

⁷¹ H. Doc. No. 174, 87th Cong., 1st sess., p. 11.

⁷² Speech at Rice University, Houston, Tex., Sept. 12, 1962.

⁷³ "NASA Authorization for Fiscal Year 1962," Report of the Committee on Aeronautical and Space Sciences on H.R. 6874, U.S. Senate, S. Rept. No. 475, 87th Cong., 1st sess., June 27, 1961, p. 3.

began to fall into more specific, coherent programs. For example, before the 1961 decisions, the family of big rockets planned for development, including the Saturn cluster and the F-1 large-thrust single chamber engine, had no definite missions. With the decision to go to the moon, these booster projects suddenly became candidates for the eventual launch vehicle system and, as such, the major pacing items for the entire program. They were given a considerably accelerated schedule, increased funding, and a very high priority.

Similarly, the decision to provide the Nation with an operational communications satellite system sparked a broad and accelerated development program as part of NASA's applications work. Funds in 1962 for communications satellites trebled. Test launchings were scheduled for later in the year of three different satellites—Relay, Telstar, and Syncom.

The lunar decision also required intermediate experimentation in long-duration stays for men in orbit and in the technique of rendezvous and docking of spacecraft. This resulted in the approval in late 1961 of Project Gemini, a two-man capsule to be launched by a modified Titan rocket and to be joined with an Agena-B rocket stage, both outgrowths of military missile and space developments.

This greatly expanded NASA roster of work required new facilities and increased personnel. The lunar landing decision and the accompanying acceleration of big booster projects (all ultimately grouped under the generic term "Saturn") resulted in the acquisition of new land and construction of facilities near Cape Canaveral; new test stands in Mississippi; modifications of a dormant defense assembly plant at Michoud, La.; and the construction of a new NASA field center at Houston, Tex., called the Manned Spacecraft Center. The number of NASA employees jumped to over 20,000 by the end of the 1962 fiscal year, as compared to 9,000 when the agency began operations.

CONCEPT OF A NATIONAL SPACE PROGRAM

The President had declared in May 1961 that space leadership "may hold the key to our future on earth." This implied not only the search for new scientific knowledge, but very practical considerations such as the impact on national defense and the national economy. The President so indicated in his report to Congress in 1962.⁷⁴ "Space competence," said the report, "is as essential for national security as it is for national growth." Hence the need for both civilian and military activities.

In the civilian sector, efforts were aimed at expanding, through satellite technology, the means for communications, weather observation and prediction, and navigation. Beyond these specific applications, the whole technological effort, including the lunar expedition, "contributed to the acceleration of the Nation's economy," the report went on, "thus creating new products, processes, materials, and opportunities for employment of skills and investment funds."

The security aspects of the technology were aimed at improving defense or preventing potentially hostile uses of space.

Recognizing the policy stated in the Space Act and elsewhere to devote space to peaceful purposes, the President said he saw no contradiction between civilian and military space activities. Both

⁷⁴ Report to the Congress, "U.S. Aeronautics and Space Activities, 1961."

served peaceful purposes. The expanded national space program, the President observed in his 1962 report, "included space projects to help keep the peace and space projects to increase man's well-being in peace."

In the same report, Vice President Johnson, as Chairman of the Space Council, endorsed the President's position that there be a national space program—an integrated, unified effort despite the activities of many agencies:

It is national policy to maintain a viable national space program, not a separate program for NASA and another for Defense and still another for each of several other agencies.

The emphasis given to a "national program" and an integrated effort reflected concern about the burgeoning space commitments and costs of more than one Federal agency. In the message proclaiming the lunar expedition, the President also asked for acceleration of the nuclear rocket propulsion project, Rover. In his subsequent report to Congress the President declared:

Every effort is being made to develop the nuclear rocket technology as rapidly as is possible so that the performance potential of these systems may be applied to the long-range space missions for which they are well suited.

The Rover project was a cooperative effort between the AEC and the space agency and managed directly by a joint AEC-NASA Space Nuclear Propulsion Office.

The Commission also stepped up its efforts to develop small, lightweight, nuclear power sources for spacecraft. This program was called SNAP (systems for nuclear auxiliary power) and employed radioisotopes and reactors. The first use of nuclear energy in space was achieved on June 29, 1961, when a small nuclear generator went into orbit as the power source for a Navy Transit navigation satellite.

These efforts came about through a doubled AEC space budget. In fiscal year 1961 the AEC had \$63.2 million for space work and \$120 million the following year. Similar increases took place in other agency budgets.

The Weather Bureau in the Department of Commerce received its first space funds in the year following the President's decision to accelerate space activities, which in this case included taking the action necessary to put the meteorological satellite program into operational status. A special satellite division was established within the Bureau, and \$50.2 million appropriated by Congress.

The first experimental weather satellite, Tiros, had been launched by NASA in its development program on April 1, 1960, following the transfer of the program from ARPA the year before. The military continued its interest and participation and were given access to the eventual operating system. This system contemplated use of the follow-on Nimbus satellite, which carried advanced cameras and stabilization devices.⁷⁵

The Defense Establishment also received a share in the general uplifting of the space program. The major decision affecting Defense and changing the tentative division of labor established by the prior

⁷⁵ This program is reviewed in a report of this committee, Government weather programs, H. Rept. No. 177, 89th Cong., 1st sess., Mar. 17, 1965, p. 85 ff.

Administration was the initiation of development of a large solid rocket motor, which was announced in the President's message of May 1961.

The expansion of Defense space efforts was reflected in the budget. For fiscal year 1962 the Defense space budget, including the additions incorporated in the President's message of May 1961, amounted to \$1,079.4 million. The final appropriations came to \$1,147.2 million, an increase of about \$350 million from the preceding year. As seen in the following table, a variety of space projects and developments were supported by this budget.

DOD space and related programs, fiscal year 1961-62

[In millions]

	Fiscal year 1961	Fiscal year 1962 proposed
Samos, Midas, Discoverer.....	\$461.2	\$541.2
Transit.....	21.6	22.4
Notus (later Advent).....	42.0	72.0
Saint.....	6.1	26.0
Spacetrack and Spasur.....	11.6	38.3
Blue Scout.....	5.6	15.0
Westford.....	3.8	4.3
X-15.....	14.9	7.0
Dyna-Soar.....	58.0	106.5
Component development, applied research, other.....	127.1	169.7
Large solid booster.....		62.0
Titan launch vehicle.....		15.0
Total.....	751.7	1,079.4

Source: "NASA Authorization for Fiscal Year 1962," report of the Committee on Aeronautical and Space Science, U.S. Senate, on H.R. 6874, S. Rept. No. 475, 87th Cong., 1st sess., June 27, 1961, p. 108. Includes identifiable DOD funding for space and space-related effort; does not include substantial amounts for construction and operation of the national ranges' support for space programs, supporting research and development (such as biomedical), or missiles such as Atlas and Thor which are used in space programs.

The system developments aimed toward or approaching operational use accounted for the bulk of the Defense funding and included navigation (Transit), communications (Advent), reconnaissance (Samos), and nuclear detection (Vela Hotel) satellites, and the ground-based spacecraft detection network (Spacetrack and Spasur). Costs on these systems had risen above early expectations, but proportionally greater increases were required for systems which were still in the exploratory or first stages of development, such as the missile launch detection satellite project (Midas), the spaceborne satellite detection and inspection project (Saint), the spaceborne ballistic missile defense project (Bambi), and the orbital glider (Dyna-Soar).

The Defense Department also was given increased funding for basic technology, some of which affected existing systems development but most of which had no immediately foreseen mission or system application, military or otherwise. This new area of emphasis involved programs in structures, guidance, control, and propulsion including, among others, the new solid rocket project and the continuing Discoverer program, which was supporting the Samos reconnaissance and Midas ballistic missile detection satellite systems by the development of capsule recovery techniques and by gathering scientific data on radiation, radiowave propagation, temperature, and meteorites.

The scientific aspect of Discoverer illustrated a growing trend of military participation in fundamental space research. This work, together with some of the component and basic technology projects,

claimed a large portion of the Defense space budget. Another example of DOD space research was the extensive use in 1961 of instrumented rocket probes. The results of this research were impressive, contributing heavily to the knowledge of space, an aim of the entire national space program. Thus, Defense space research led to the measurement of absolute radiation fluxes in the ultraviolet region of the 40 brightest stars and to the discovery of a dense band of micrometeorites circling the earth at an altitude of 100 miles or so.

The wide range of Defense space activities indicated that the new decisions for a national space program had brought with them no precise definitions of the division of labor. In fact, such attempts in that direction had been virtually abandoned. The communications area, for example, once had been divided in such a way as to give NASA responsibility for passive satellites like Echo, and Defense responsibility for active repeaters. In the Kennedy administration both Defense and NASA embarked on active synchronous communications satellites in their Advent and Syncom projects. Both also worked on passive devices. Defense furthered its plan for orbiting a belt of dipoles in the form of tiny copper filaments in space, a project which became known as West Ford.

INTERAGENCY AGREEMENTS AND SUPPORT

Such heavy involvement of each agency in similar areas of technology and investigation required a closer degree of coordination. It was recognized, too, that expansion could get out of hand and that clearer lines of responsibility would eventually have to be established delineating specific tasks. Toward these ends the work of the Aeronautics and Astronautics Coordinating Board (AACB) was stepped up. There also emerged a new pattern of top-level understanding in the two dominant agencies involved in space. As a result of direct, personal contact, Defense Secretary McNamara and NASA Administrator Webb entered into a long series of agreements which bound their respective agencies to both increased cooperation and more definite responsibilities.

One of the major results of high-level attention to coordination was the creation in July 1961 of the DOD-NASA large launch vehicle planning group. This group was given the task of formulating a national program to meet the long-range needs of both agencies for large space vehicles. Their work resulted in further agreements signed by the agency heads initiating the development of certain large liquid-launch vehicles, the development of large solid motors, and the development of the Titan III launch vehicle. This last vehicle was to be an adaption of the basic Titan II missile, with the addition of strap-on solid rockets for the purpose of putting into near-earth orbit payloads of 5,000 to 25,000 pounds.

These projects were not to be jointly conducted but to be managed singly by each agency. NASA continued to develop the liquid rocket family, necessary for the lunar expedition and other big payload missions. The Defense Department was given the task of developing solid rockets, including Titan III.

This separation of tasks was expected to eliminate unnecessary duplication. Similarly, by other actions, NASA agreed to utilize some of the DOD bioastronautics capability to meet its own needs,

and DOD decided to participate in the NASA Gemini program in pursuit of its interests in the techniques of manned rendezvous in space.

A joint DOD-NASA study on facilities and resources required to support the Apollo manned lunar-landing program also was completed during 1961, leading to an initial cooperative arrangement. Cape Canaveral was chosen as the launch site for the program. Defense was already located on the Cape, where it managed the launching and support of missile and space vehicles for both itself and NASA. An additional 80,000 acres were purchased by NASA for Apollo. The Air Force by this early arrangement was made the range manager in support of the Apollo program.

The steps toward increased interagency coordination were recorded in program successes. Among these were the Project Mercury achievements, culminating in the first American manned orbital flight in early 1962. Approximately 18,000 DOD personnel were involved in a typical Mercury shot. The total cost of Defense support of the Mercury program amounted to \$133 million, of which \$100 million was reimbursed by NASA.⁷⁶

Much of the success of the team effort in the Mercury program was due to the full, detailed planning that preceded actual operations. As early as August 1959, the then Secretary of Defense had set forth the authority and responsibility of the Department in support of the program. Later a clearly defined chain of command was instituted. A DOD representative, Maj. Gen. Donald N. Yates, U.S. Air Force, was designated as a single point of contact between DOD and NASA as well as within the Defense Department. Direct coordination between the DOD support elements and the DOD representative was authorized. Only in a few instances were matters referred to the Joint Chiefs of Staff for their approval.

Support services for Mercury came from both NASA and Defense. This situation made the problem of coordination more difficult. On the other hand, the final success of the Mercury venture was all the more impressive in the face of such complications. Careful integration of services had to be achieved in tracking, communications, telemetry, medicine, and capsule recovery.

This combined effort established a pattern for future launch and range operations. As the DOD representative, Maj. Gen. L. I. Davis U.S. Air Force, who succeeded General Yates, said in his final report to the Secretary of Defense: "Future space-flight operations can be effectively supported by applying the experience and procedures derived during Project Mercury." Equally significant was the gain to the Department's own space program. Defense involvement in the manned space project "contributed greatly to the Department of Defense's knowledge and experience," reported General Davis, "in areas of launch, network, recovery, communications, and medical space operations."⁷⁷

The pattern of NASA reliance on Defense Department support continued to be more pervasive than one project alone would indicate. NASA looked to Defense experience and work on the Navy Transit navigational satellite for eventual application to a commercial or

⁷⁶ Summary report, "DOD Support of Project Mercury," submitted to the Secretary of Defense by the DOD representative for Project Mercury Support Operations, Sept. 11, 1963, p. 51.

⁷⁷ *Id.*, p. 78.

civilian satellite-navigation system, and an agreement signed in March 1963 instituted a cooperative arrangement to provide for this development. Management procedures also were involved. NASA continued to use the Defense Department procurement rules set forth in the Armed Services Procurement Regulations. The agency also relied on Defense contract management services such as contractor plant representatives and adopted Defense procedures for common cost and work progress scheduling, using the new PERT methods.

Constant involvement in Defense activities and continuing need for high-level coordination prompted NASA in late 1962 to appoint a Deputy Associate Administrator for Defense Affairs. Named to the new post was a retired Navy admiral, Adm. W. F. Boone. His job was to maintain liaison between the two agencies and to act as the main point of contact between the Administrator's office and the military services.

For a while this pattern of reliance and coordination obscured the fact that NASA was becoming the dominant space agency with increasing yearly budgets. As it gained a position of dominance, NASA was not content to rely so heavily on the Defense Department for essential supporting services. Its growing size and ample funds gave it both increased bargaining power and heightened requirements, and thus NASA began to ask for a voice in military-managed projects needed by both Defense and NASA. For instance, when NASA decided to use the Air Force Agena upper stage, developed for the Discoverer, Samos, and Midas projects, it sought closer involvement in the planning and production processes. As a result of an agreement signed in September 1963 between the Air Force Systems Command and NASA, provision was made for special coordination groups at the working level affecting each vehicle coming off the assembly line. This agreement also insured NASA a place in the planning effort for other launch vehicles by making the agency a member of the Air Force Configuration Control Board for the Atlas, Thor, and Agena vehicles.

NASA asserted its own identity elsewhere in the Defense complex by establishing in March 1962 independent field installations at the launch facilities of the Atlantic and Pacific missile ranges. At the same time, Defense began to show signs of a growing dependence on NASA. For instance, the Air Force, through its Systems Command, established offices directly at NASA headquarters to provide support to NASA and to enable the military to become fully informed of the wide range of NASA activities.

Interagency organizational relationships were important to an expanded national space program, but so was internal realignment, particularly within NASA, which had to come to grips with the organizational problems posed by Apollo and other policy and program decisions of the Kennedy administration. The Wiesner report had recommended strengthening the top management of NASA including a reorganization of the agency to give more attention to specific areas of concern, such as applications, manned space, and technology. The emphasis given to these areas by the President's decisions of May 1961 focused attention on such recommendations for reorganization.

CENTRALIZING NASA MANAGEMENT

The administrative setup that had existed in 1960 had to be adjusted to new decisions and new needs. Immediate responsibility for the

direction of NASA activities then rested in the program offices below the level of the Administrator and his top assistants. Projects overlapped between the program offices, and complementary activities in some cases were unduly separated. For example, there was a program office for launch vehicles separate from and coequal with flight programs, the latter office comprising all systems and applications development. A separate office, with the same status as the others, was given to life sciences. The same was true with technical information.⁷⁸

The situation called for more centralized management. Many suggested that a "moon czar" be established at NASA headquarters. It was difficult to embrace both concepts at the same time. A director of Apollo with more power and authority than other project managers might cause other projects to be shunted aside and impede the quest for effective top management control over the whole complex of programs and field centers.

The core of the new reorganization effected in November 1961⁷⁹ was the strengthening of central authority in the Office of the Associate Administrator, Robert C. Seamans, Jr. Still reporting directly to the Administrator, the Associate Administrator came to act as the general manager for the whole agency. The six program offices for major functional areas reporting to Dr. Seamans were regrouped and consolidated into four: Manned Space Flight, Space Sciences, Advanced Research and Technology, and Applications. The Office of Business Administration, previously coequal with the other program offices, was brought up to Dr. Seamans's level as the Office of Administration, along with its complement of units for procurement, financial management, audit, personnel, inspection, and the like. An Office of Programs also was established within the level of the Associate Administrator, with separate divisions for resource programming, facilities coordination, management reporting, and quality control. These expanded staff resources gave the Associate Administrator strong financial and management tools to supervise the 4 program offices and the 10 field centers or stations. Previously the field units had reported to individual program offices, but now the line of authority and command ran directly from the Associate Administrator to the field.

The reorganized program offices reflected the areas of agency emphasis. The new Manned Space Flight Office, to be directed by D. Brainerd Holmes, would encompass direction of the mammoth Apollo program, absorbing in the realignment the functional areas of launch vehicles and aerospace medicine, which previously were in coequal program offices of their own. The new Office of Applications reflected the interest in practical benefits of commercial and consumer value. The new Office of Space Sciences emphasized the broad interests of the scientific community, with separate divisions for biosciences, lunar and planetary probes, geophysics, and astronomy. In keeping with the new hardware and systems orientation of NASA, the Office of Advanced Research was renamed the Office of Advanced Research and Technology, with divisions for nuclear systems, propulsion, space vehicles, electronics, aeronautical research, and space research.

⁷⁸ See 1960 NASA organization chart in appendix B of this report, faces p. 122.

⁷⁹ See 1961 NASA organization chart in appendix B of this report, faces p. 122.

With the centers no longer reporting directly to them, these program offices became more identified with staff rather than line functions. Although the centers continued to look to the program offices for project direction, they were involved in many projects rather than only one or two identified with a particular program office.

The centralization of agency management was not intended to destroy the initiative and relative freedom of the field centers, where actual management of individual projects on a day-by-day basis continued. The centers retained a large measure of authority for technical management and procurement. In part, NASA had made the centers its prime contractors for certain systems developments, whereas, by contrast, the Defense Department often relied on industrial contractors to do this integrating job, often at the direction of special project offices. For instance, Jet Propulsion Laboratory was responsible for the Ranger lunar probe and the Goddard center for the Tiros and Nimbus weather satellites. In other NASA projects complete authority as systems development manager was not explicitly given to centers, and, often, this was not possible, as in Apollo, with several parts of the project residing in different centers. Therefore, management problems would remain, and further organizational and management changes would be recommended or instituted as projects encountered difficulties and schedules slipped, or as important work areas seemed neglected. Among the centers, which had grown in size and number, mainly to accommodate the Apollo program, there would be problems of coordinating activities and preventing needless duplication. Between the centers and the headquarters-level, autonomy would wrestle with review and direction. The Jet Propulsion Laboratory, as a university-connected nonprofit contractor managing an important sector of NASA activities, would pose a separate set of problems, since it was not precisely an in-house center nor a conventional contractor in industry.

Overriding all other organizational problems was the impact of the Apollo program on the whole space agency. All efforts had to be bent toward successful completion of the moon project. Certainly it was no ordinary project taking its place alongside others which had conventional project managers who gave concentrated attention to the limited tasks in hand. Apollo was the very agency itself—at least in the public assessment of the space effort. Its omnivorous demand for talents and resources threatened to convert the whole agency into a single project. If other areas of concern, such as space sciences and aeronautics, were to be properly attended, and a space career projected for NASA beyond the moon landing, then some viable relationship would have to be maintained between Apollo and the rest of the agency in an organizational sense.

The NASA field centers, including JPL, had within them impressive talents and varied resources for technical development and technical management. These would have to be—and were being—reoriented from the more leisurely and more widely separated research preoccupations of the old NACA days toward an integrated effort in execution of NASA's missions, of which the major one was landing a man on the moon by 1970. The largest part of the work—about 90 percent in dollar terms—would be done by industry, with the centers serving as procurement, testing, and technical management organizations. Procurement had increased more than threefold in one fiscal

year (1963), signifying large new management tasks for the centers. And because of the complex system relationships and exacting demands for performance in the Apollo program, NASA drew upon large industrial organizations for special contract services in Apollo systems analysis and ground test and checkout of equipment.

Contract arrangements were made in 1962 with Bellcomm, a specially created subsidiary of American Telephone & Telegraph Co. and with General Electric Co. for these purposes. With the notable exception of JPL, NASA decided not to use nonprofit organizations as adjuncts to its in-house resources, relying instead on industrial organizations to perform systemwide studies and systems engineering. In seeking these additional technical management services from industry, NASA took a somewhat different route than did the Air Force, its chief military counterpart for space activities, which relied more heavily on nonprofit contractors for technical support.

AIR FORCE REORGANIZATION FOR SPACE

By the time NASA's 1961 reorganization was effected, the Air Force had gained responsibility for practically all future research and development of Defense space projects. This was ordered in a DOD directive of March 16, 1961. Except for some existing projects lodged in the other services, such as the Navy's Transit navigational satellite and the Army's Advent communications satellite, and apart from ARPA's advanced research in designated areas, the Air Force became for all intents and purposes the military space agency. Exceptions to this arrangement could be made only by the Secretary of Defense. Another directive in February 1962 assigned responsibility to the Air Force for support of NASA projects.

Responding to its enlarged mission assignment of March 1961, the Air Force effected internal reorganizations. The Air Research and Development Command was reconstituted as the Air Force Systems Command; and to give special recognition to the space assignment, the Space Systems Division was organized as one of four component divisions of the command (the other three being Ballistic Systems, Aeronautical Systems, and Electronics Systems). Supporting the Space Systems Division with systems engineering, technical direction, advanced research, and other technical tasks was the Aerospace Corp., a nonprofit entity organized by the Air Force in 1960 as a successor to Space Technology Laboratories, Inc. Other nonprofit corporations, such as MITRE in support of the Electronic Systems Division, also worked for the Air Force as technical managers for systems development.

The organizational emphasis which the Air Force gave to its space assignment and the management prerogatives which it believed to be associated therewith, threw the Air Force into potential conflict with a Defense review agency—the Directorate of Defense Research and Engineering. The 1961 directive had specified that the scope of military space research and development to be undertaken by the Air Force would be defined by D.D.R.&E., which would review all space proposals prior to transmission to the Secretary of Defense.

Established pursuant to the Department of Defense Reorganization Act of 1958, the D.D.R.&E. had broad powers of review and approval over Defense research and development programs and projects. After a few years of experience in learning the dimensions of its job,

the D.D.R.&E., during the tenure of Secretary Robert S. McNamara, exercised its authority in a much more direct and positive way. It became the strong staff arm of the Secretary to keep rein on costly new development projects. This it would do by insisting on more precise requirements, better definition of programs in terms of money costs, technical problems, and time schedules, and cost effectiveness analyses to determine whether projects should be advanced beyond the development stage into full-scale production and deployment which, in the case of contemporary weapon and space systems, frequently entailed multibillion-dollar outlays.

The Air Force had just emerged from a 5-year crash program for ballistic missiles, when the urgencies of the moment in the face of a growing Soviet threat were more important than low costs or management methods. Missiles had to be built—and built quickly—to counter Soviet progress in that area and to insure a sufficient degree of relative invulnerability which could enable this Nation not to relax, but to reassess and refine and improve. Most of the decade of the 1950's was characterized by a proliferation of missile projects, spurred by new and developing technologies and sharp interservice as well as interindustry competition. This was a decade of duplication, of quick obsolescence, of cost overruns, of costly failures, and of outstanding achievements.

From a management standpoint, Secretary McNamara was both the beneficiary and the critic of these earlier developments. He was the beneficiary in the sense that crash missile programs had given the United States the military posture which would enable it to pause and reexamine. He was a critic in the sense that a strong military posture did not necessarily entail costly duplication and waste. The Air Force, along with the other military services, was experienced in procurement, had extensive resources for management, and recognized the need for constant improvement in these areas. Nevertheless, as the department most heavily involved in the missile programs of the preceding years, and as the department most heavily committed to the potentially costly but not too well defined area of military space operations, the Air Force would encounter many collision points with the Defense-level review agencies.

At an earlier period the Air Force had contended for space dominance with ARPA, which could have become the military space agency above the services. That issue was resolved by limiting ARPA's concern to designated fields of advanced research and by a policy of turning over maturing development projects to the services for execution. The Air Force also had contended with its sister services, and this issue had been resolved largely in its favor when it acquired responsibility in 1959 for military space booster developments and in 1961 for military space research and development generally.

Since national policy had decreed, through the enactment of the National Aeronautics and Space Act of 1958, that a large civilian effort would be devoted to space exploration outside the military, the Air Force role in space was bound to be more circumscribed than otherwise. The decisions on large new projects or substantial commitment of Defense funds for space would rest not with the Air Force, but with the Secretary of Defense and his staff agencies of review. Between the high level reviewers and the action-oriented elements in the field, there would be differences of opinion and disagreements.

VI. REEVALUATION OF THE SPACE PROGRAM: 1963-65

SPACE PROGRAM CRITICS

The swift expansion of the U.S. space program was signaled by a doubling of the NASA budget in fiscal year 1962 and again in 1963, this time going from \$1.8 billion to \$3.6 billion. A more modest increase in the Defense space budget brought the military level of space activity to \$1.5 billion for 1963. These increases came at a time when public interest and enthusiasm for the space program were at a high point. The success of the Mercury program had been shown dramatically over nationwide television. The John Glenn orbit in February 1962 was seen by the largest television audience recorded up to that time. Continued Russian feats in space, such as the tandem and 4-day manned orbital flights, also spurred keen interest in an expanded U.S. space program.

But for most of 1963 a different atmosphere prevailed. It was difficult to maintain public enthusiasm when there were few visible results from the preparatory work being done for the Apollo expedition, which now occupied NASA's major attention upon completion of the Mercury shots. There was also a slackening of other program launches. In 1963 NASA attempted only 13 major launches, half the figure recorded in 1962, and substantially below the 34 to 43 flights originally scheduled for the year. Critical comments casting doubt on the lunar goal also appeared from segments of the scientific community. The sense of urgency over this goal was further affected by press reports of a statement made by Soviet Premier Khrushchev on October 26, 1963, that his country "at the present time" did not "plan flights of cosmonauts to the moon."⁸⁰ Finally, the high costs of the space program met a more questioning reaction in Congress. Budget requests totaled \$7.6 billion for all Government agencies for fiscal year 1964, including a proposed \$5.7 billion for NASA.

NASA's posture before Congress when submitting its budget request for fiscal year 1964 was also affected by fund changes and transfers made in its fiscal year 1963 budget. The fund transfers, amounting to \$52.4 million in the category of research, development, and operations, were due to major program changes, including the decision to accomplish the lunar landing by the lunar orbit rendezvous method rather than direct ascent or earth orbital rendezvous.

These transfers were permitted under the earlier legislation, which authorized funds in a lump sum for research, development, and operations, allowing any changes the agency wanted to make within the program structure. In addition, NASA could transfer up to 3 percent of such funds to construction of facilities. A measure of discretion and freedom had been granted by Congress in recognition of the fact that uncertainties in technology demanded flexibility to adjust to

⁸⁰ *Astronautics and Aeronautics*, 1963, GPO, 1964, p. 401.

rapid program changes. The House Space Committee in 1962 warned, however, that the same transfer and reprogramming authority might not be granted in the future.

As a result of the review of NASA actions taken in late 1962, the Congress finally imposed considerable limitations on the agency when it enacted the funding authorization for fiscal year 1964. The amount for research and development was separated into 22 separate line items with ceilings imposed on each amount. Administrative operations became a separate budget category.

Further restrictions were incorporated in the legislation for fiscal year 1964. Reprogramming could not take place unless prior notice was given to the authorizing committees of the House and Senate, and then only if, within a 30-day period after notice was given, each committee had not transmitted any written objections to NASA. The amounts that could be transferred or reprogrammed were also curtailed. Some of these restrictions were new for NASA but had been imposed on the Defense Department funds for some time.

More significant than the curbs put on NASA discretion was the size of the cut made on its budget request. The request for fiscal year 1964 was \$5.71 billion. The House cut the authorization bill by \$508.2 million, but the Senate restored \$307.8 million. The largest single amount restored was \$120 million for Apollo. After final congressional action, the agency received \$5.35 billion in authorizations and \$5.1 billion in actual appropriations. This cut of about \$600 million was the largest, both in absolute and relative terms, ever made on a NASA budget request.

Final congressional action on the appropriation for fiscal year 1964 did not come until that fiscal year was nearly half over. Agreement was reached on the independent offices appropriation bill on December 10, 1963. The final figure of \$5.1 billion consisted of \$3.926 billion for research and development, \$680 million for construction of facilities, and \$494 million for administrative operations. The largest reduction took place in research and development with \$425 million cut from the original request of \$4,351,700,000.

RIISING SPACE COSTS

The agency itself was ready to tighten its purse strings, not only in order to stay within reduced budgets but to insure that savings be realized wherever possible in the burgeoning space program. NASA early had recognized that as a research and development agency penetrating unknown areas of knowledge and advancing new technologies, its costs would be difficult both to estimate and to keep down, particularly in a period of rapid expansion. Nevertheless, by 1963 the program had settled down sufficiently so that more precision and economy were possible without inflicting undue harm to the initiative and flexibility needed for a new scientific and technological effort.

The difficulty in cost estimation was demonstrated by the completed Mercury project. Originally its costs were put at \$200 million, but final costs brought the total to \$400 million.⁶¹ This increase was due in part to revisions for which the extra funding requirements were known in advance, but \$50 million constituted cost overruns of the original contract price on the spacecraft alone. An additional \$15

⁶¹ Aviation Week and Space Technology, Dec. 28, 1959, p. 16; NASA, Mercury Project Summary, GPO, 1963, p. 25.

million in cost overruns was incurred in the contract for Mercury tracking and ground instrumentation.

Other programs also had cost overruns. As of the middle of 1963, the Nimbus meteorological satellite project had overruns of more than \$9 million out of a total contract amount at that date of almost \$22 million. The orbiting astronomical observatory by the same time had \$34 million in overruns out of total contract amount of over \$92 million.⁶²

Following the 1962 report of an interdepartmental committee on government research and development (Bell report), a group was formed in NASA to study procurement. Its recommendations, submitted in 1963, asked for more incentive contracts and a decrease in letter contracts. Procurement also was given further top-level management attention and centralization when in March of 1963 a Deputy Associate Administrator for Industrial Affairs was named, with the Director of Procurement reporting to him. In a later move, NASA agreed to cooperate with the Defense Department in its newly planned system for evaluating the performance of contractors to assist the agencies in the award of future contracts.

NASA REORGANIZATION OF 1963

In 1963 NASA also reevaluated its entire organizational scheme. The 1961 organization had been eroding over the course of 2 years. Most of the changes had affected the manned space flight program, which had charge of Apollo. In August 1962 the Launch Operations Center was placed under the control of the Office of Manned Space Flight rather than reporting directly to Dr. Seamans, the general manager. The Pacific Launch Operations Center was at the same time placed under the Office of Space Sciences. Another increase in the stature of the Apollo organization took place when Brainerd Holmes became a Deputy Associate Administrator in addition to being Director of the Manned Space Flight Office.

Still, the agency displayed a tentative attitude with respect to Apollo organization and management. Although the program was receiving the bulk of funds and agency personnel, NASA was reluctant to give the program distinctly separate and dominant status organizationally for fear of breaking down the balance sought in the 1961 organization or diminishing the central authority of the agency. By November of 1962 the Launch Operations Center in Florida was again reporting directly to Seamans rather than to Holmes.

These somewhat confused lines of authority and repeated improvisations undoubtedly contributed to the eventual resignation of Holmes on June 12, 1963.

Later in the year another major reorganization was put into effect.⁶³ The new arrangement sought to give all projects, including Apollo, a more direct call on resources within the agency. In effect, the program offices were returned to the status of line agencies, with the different field centers and installations reporting directly to them instead of to top management. At the same time the program office directors were elevated to Associate Administrators. Reporting to the Associate Administrator for Manned Space Flight were the Mar-

⁶² 1964 NASA authorization, hearings of the Committee on Science and Astronautics, U.S. House of Representatives, 88th Cong., 1st sess., March-May 1963, pt. 3(a), pp. 1766-1768.

⁶³ See NASA organization chart for 1963 in appendix B of this report, faces p. 122.

shall Space Flight Center at Huntsville, Ala.; the Manned Spacecraft Center at Houston, Tex.; and the Launch Operations Center in Florida. The Office of Space Sciences and the Office of Applications were merged into one, and reporting to the new Associate Administrator for Space Science and Applications were the Goddard Space Flight Center in Maryland, the Pacific Launch Operations Office in California, the Wallops Station in Virginia, and the Jet Propulsion Laboratory. Advanced research and technology also was placed in the charge of an Associate Administrator, supervising the old NACA research centers of Ames, Langley, Lewis, and Edwards.

This realignment responded to growing emphasis on project management. The major projects of the centers now conformed more closely to the offices they reported to. For instance, the Marshall Center was largely concerned with the development of the Saturn family of rockets destined for use in Apollo. The Houston Center also concentrated on capsule development and astronaut training for the Gemini and Apollo programs. And the Apollo program was likely to be the exclusive preoccupation of the Launch Center in Florida.

Overlap continued to exist in the other program offices. The Goddard Center was not only engaged in applications development but also managed the work directed by the separate Office of Tracking and Data Acquisition. There was also a connection between the tracking operation and the Launch Operations Center which reported to the Manned Space Flight Office. Even more of an overlap existed in the Advanced Research and Technology area, since its laboratories and research personnel were supporting the entire range of NASA projects. Nevertheless, the new arrangement contributed to the unification of resources and activities needed to achieve success on particular projects.

The agency, in explaining the new structure, stated that each center now would have a single point of contact at headquarters for all center and program matters in order to assure integration of technical and management activities and to speed decisionmaking. At the same time, the centers were given closer supervision by program offices than they could receive when all of them reported to the Associate Administrator. The change, in this respect, was pointed not toward lessening the authority of the top management of NASA but toward giving more effective central direction from the supervisory level below the general manager. The change gave the general manager, as the top Associate Administrator, more time for agency-wide direction, which was the original purpose of the 1961 reorganization.

In this connection, the overall management staffing at headquarters was strengthened, specifically in the agencywide administrative fields of programing, budgeting, policy planning, liaison, and contracting. Given the project orientation of the program offices and the overlap of center work, the new reorganization would not completely settle the question of center management. Further arrangements and understandings would have to be worked out to insure uniform procedures and policies. In this sense, NASA's statement that there would be only one point of contact at headquarters for the centers could not be literally followed. There remained the continued problem of balancing field center autonomy and strong central management

and direction. Achieving this balance would require constant attention, especially with the heavy demands of Apollo, the large budget of the Agency and its enlarged personnel force of 34,000.

DOD MANAGEMENT OF SPACE PROJECTS

In the Department of Defense similar problems of balancing central management and service autonomy had a bearing on military space activities. In this case, the matters at issue were not only project management but also program and budget review. Again, the heavy costs and difficulties involved in new fields of technology were the motivating forces behind change. Affecting the disposition of these forces was the specter of costly duplication with NASA as project costs multiplied and new potentials for space exploration emerged.

The mood of skepticism that began to prevail within the top level of Defense management in 1962 and later developed into a policy of strong restraints on the scope of Defense space efforts had its roots in many factors and conditions. Not the least of these was the rising trend in expenditures. This trend was not restricted to space. Total Defense expenditures had gone from \$38.4 billion in fiscal year 1957 to \$48.2 billion in fiscal 1963. Within this \$10-billion increase, expenditures for research and development had doubled, from \$3.4 billion in fiscal 1957 to \$6.8 billion in fiscal 1963.⁸⁴ The jump in research and development volume was, to some extent, more apparent than real, since general prices had risen over the period, and changes in budget classifications caused the transfer of various appropriations from procurement and other accounts to the research and development category. Nevertheless, the magnitude of individual programs, the large costs, and the technical difficulties made research and development a matter of intense management concern.

At the end of 1962 the top management team in the Department noted that there had been very few new proposals for space systems and projects beyond the roster established by ARPA in 1958. The projects carried on in 1962-63 were much the same as those begun in 1958. Some important ones had been transferred to NASA, such as the man-in-space effort, the big liquid-fueled booster development, the meteorological satellite, some scientific satellites and probes, and nuclear propulsion. A few had been canceled while in the ARPA stable, such as the space station plan (Suzanno).

The oft-stated declaration that there were no new space proposals seemed to imply that there would not be any new Defense space projects. The top management of Defense began to display growing impatience with military space proponents who suggested a broader effort. For example, John H. Rubel, Deputy Director of Defense Research and Engineering, in a speech of October 9, 1962, discounted prevailing theories about military space needs.⁸⁵ Mr. Rubel prefaced his remarks with a statement that the Defense spending level for space was "as close to the optimum size as we can make it in the light of all the uncertainties that must accompany such a program." "In fact," he said, "we probably err on the side of allowing too generous a margin of safety for the effects of these uncertainties." Henceforth,

⁸⁴ DOD Annual Report, 1957, p. 304; DOD Annual Report, 1963, p. 324; "Fiscal Trends in Federal Research and Development," Report of the Subcommittee on Science, Research, and Development of the Committee on Science and Astronautics, U.S. House of Representatives, 88th Cong., 2d sess., Feb. 26, 1964, p. 13.

⁸⁵ DOD Press Release No. 1642-62, Oct. 9, 1962.

in approving space projects, the Department would emphasize hard military requirements. Despite the multitude of "fascinating and potentially useful projects" that the Department might undertake, said Mr. Rubel, they could not be supported "unless we can satisfy ourselves that these efforts contribute to our military mission."

Mr. Rubel implied that various proposals put forth did not meet these high standards for research and development but only served abstract doctrines about the military role in space. Such doctrines included the concept that control of space meant control of the earth, that space would be the future battleground, and that space was merely the extension of the air regime, calling for a corresponding extension of American military superiority.

Precisely stated military requirements hardly would explain all the existing Defense space efforts, as Mr. Rubel himself recognized. An outstanding example was the new Titan III space booster development, estimated to cost about \$1 billion and likely to consume a large part of the yearly Defense budget for space. This large development project was not initiated to satisfy a specific operational requirement, although it was soon assigned as a launch vehicle for the Dyna Soar orbital glider which itself had no definite military mission as yet established. The same could be said to an even greater extent about very large solid rocket engine efforts, space probes, radiation studies, materials research, nuclear power sources, electrical ion propulsion, biastronics, sensor developments, laser technology, and extensive general supporting research and development. Much of this work came to be dubbed "building block" efforts, which was a shorthand way of saying that despite the lack of military systems requirements, an adequate base of experience and hardware should be gathered together as insurance for the future when later systems decisions might be necessary.

The existence of such wide-ranging space efforts indicated that the new policy statements of the Department were manifestations of doubt regarding new proposals rather than opposition to existing projects. Nevertheless, separate reviews began to inhibit even old projects as closer scrutiny was made of costs involved compared with progress achieved. As noted, many of the programs dated back to the early ARPA space roster.

COMMUNICATIONS SATELLITE REVIEW

One was the communications satellite program, once known under the generic title of Notus. From this broad program had come experimental satellites, such as Courier and Score, and a plan for synchronous satellites to test system feasibility. The execution of the plan had been divided between the Air Force and the Army, alternating as executive agents for ARPA. In addition to the confusion of jurisdictional lines of authority, the early efforts were subjected to changes in program concepts and schedules for an eventual operational system. In 1960 the communications satellite effort, directed ultimately to a synchronous or stationary orbiting satellite system, was assigned to Army management, with the Air Force responsible for the launch vehicles. Although classified as a research and development project, it was unclear whether this program, called Advent, would only test feasibility of a system or actually become an operating system.⁸⁶

⁸⁶ The history of Project Advent is reviewed in annex II of a report of this committee entitled "Satellite Communications," H. Rept. No. 178, 89th Cong., 1st sess., first issued as a Military Operations Subcommittee print, 88th Cong., 2d sess.

In early 1961, as program difficulties became evident, Secretary McNamara decided to make no changes in the existing service management and contract structure for Advent, but he emphasized that the Director of Defense Research and Engineering would "maintain cognizance over technical and managerial problems associated with the Advent project." He also reaffirmed that Advent was the only approved DOD project for satellite communication, assigned to the Army as a Department of Defense undertaking.

Later in the year a D.D.R.&E. team surveyed the Advent effort and noted that the estimated costs had increased steadily since the commencement of the program. Total costs to complete the project were estimated at \$140 million in February 1960 and \$325 million in September 1961. Overruns on the contracts, the team reported, amounted to \$109 million. When Dr. Brown, the Director of Defense Research and Engineering, reviewed the team report, he asked that the program be carefully reviewed and redefined in more realistic terms.

Finally, after realizing that the entire program was technically overambitious and would not meet the time schedules, the Secretary of Defense effectively stopped the Advent effort. In short, the situation was this: the satellite segment schedule had slipped about a year; technical difficulties in the NASA Centaur booster development meant a 3-year delay in the launch schedule; and the triode tube technology for the prospective system had become obsolete. Following a new review, in May of 1962 the Secretary directed the cancellation of the major satellite contracts in Advent. Advent spending had amounted to about \$170 million, of which only about \$50 million worth of equipment and data was salvageable.

A revised program proposing a medium-altitude communication satellite (MACS) system was approved by Secretary McNamara, but development was held back for a program definition phase to reassess each item in the program. After completion of this program definition in August 1963, the MACS program was further delayed until the summer of 1964 while Defense representatives tried to work out an agreement with the Communications Satellite Corp. to provide the desired services. Failing in this effort, which was reviewed in an earlier report of this committee,⁸⁷ the Department revised its communications satellite program again and is now proceeding belatedly toward the development of an "initial system," to be launched in 1966 by Titan III-C test launches.

DOD CUTBACKS

Space programs other than communications also received pruning in 1963. Intensive reevaluation of several existing projects actually began earlier. For instance, the Saint, space-borne satellite inspector project, initiated by ARPA, was reassessed by the Defense administration and Secretary McNamara. Major difficulties were identified in that part of the program directed to the techniques of rendezvous with and inspection of unidentified or noncooperative satellites. As a result of studies, work was suspended in 1963 on the development of an unmanned prototype coorbital system. The inspection system was relegated to the level of definition study.

⁸⁷ Ibid.

The space-borne ICBM alarm project also was "reoriented." Although during 1963 the flight test program, originally called Midas, achieved success in actually detecting live ballistic missile launches by means of infrared sensors carried in an unmanned satellite, the Defense Department declared that there still remained "unanswered questions regarding the technical feasibility, complexity, and cost-effectiveness of a space-borne ballistic missile alarm system."⁸⁸

Another related project, Bambi, which envisioned a space-borne anti-ballistic missile defense system never got going at all. Like the ICBM alarm and satellite inspector projects, the Bambi program met not only hard questioning by top Defense officials with respect to its costs and technical feasibility but also competition from alternative programs, some within the Department and others in NASA. For instance, ground-based radar was favored by top DOD officials for the job of ballistic missile early warning. Similarly, Army's Nike-Zeus and ARPA's Project Defender, although also technically difficult and without firm approval for an operating system, competed strongly with Bambi. Lastly, the rendezvous and docking techniques to be gained by NASA in its Gemini project were emphasized in place of the Saint project, despite the fact that noncooperative satellites were not involved in this NASA work.

A much more costly program was the manned orbital glider, Dyna-Soar. Indications that the Defense Department would eventually cancel this program were found in statements made by top Defense officials as early as January 1963. In his appearance before the Armed Services Committee of the House during hearings on the fiscal year 1964 budget, Secretary of Defense McNamara cautioned that "some very difficult technical problems still remain to be solved in this program, particularly in connection with the mode of reentry." It did not seem, however, that the question was altogether a technical one. The Secretary himself indicated that the system would work eventually. The costs and the competition of NASA projects were what bothered him:⁸⁹

The real question is, What do we have when we finish it? It will cost to complete, in total, including funds spent to date, something on the order of \$800 million to \$1 billion. The question is, do we meet a rather ill-defined military requirement better by proceeding down that track, or do we meet it better by modifying Gemini in some joint project with NASA?

MILITARY MAN-IN-SPACE DISPUTE

The competition with NASA had become a bedeviling problem for the Defense Department by 1963, particularly where the area of manned space was involved. It was over the question of the military role of man in space that the Secretary and the Air Force were sharply divided. Faced with the probable cancellation of Dyna-Soar, the Air Force was seriously concerned that there would be no such role. This concern was heightened by the equally dim prospects for future manned bombers now that the B-70 project had been cut back and

⁸⁸ Report to the Congress, U.S. Aeronautics and Space Activities, 1963, p. 40.

⁸⁹ Hearings on Military Posture, Committee on Armed Services, U.S. House of Representatives, 88th Cong., 1st sess., January-February 1963, pp. 467, 471.

the Skybolt canceled in late 1962. Moreover, reliance on missiles also reduced the manned role, and in the area of ballistic missiles development was coming to a close.

This concern of the Air Force was not restricted to doctrinal abstractions about the role of military man in space nor to the problem of a diminishing workload and resource base. Air Force planners seriously considered that manned space flight held out important military promise, not only to counter Soviet developments and potentially hostile spacecraft, but also to enhance certain existing military missions, such as reconnaissance, intelligence, command and control, electronics countermeasures, detection, and bombardment. The job of bombardment had been withdrawn from the mission of Dyna Soar. Questioning the feasibility of an orbital or other space bombardment system as compared with missiles and desirous of avoiding an arms race in space, the Administration announced that the United States did not intend to orbit weapons of mass destruction in space. Later statements of the same kind by the Soviets finally resulted in a mutual policy position, given international recognition in the United Nations.⁹⁰

The Air Force, however, was unwilling to rely completely on NASA. Recognizing that NASA's efforts would contribute to needed basic technology, the Air Force still did not believe that certain techniques or systems would be developed by NASA. Consequently, the Air Force submitted a number of manned space projects to the top review levels of the Department throughout 1962 and 1963. All of these plans, manned orbital development system (MODS), Blue Gemini and the like, were returned to the Air Force for more analysis and definition. Defense officials sympathized with Air Force concern but under the prevailing policies of restraint in space work, cost effectiveness, and precise program and requirements definition, the specific proposals did not survive.

Instead, the Department looked with more and more favor to depending on NASA for manned space efforts. There were various pressures upon the top management to pursue such a policy. These were first highlighted dramatically by an incident that took place in the middle of 1962.

The New York Times reported on its first page on June 11, 1962, that the Defense Department was "embarking upon a man-in-space program to prevent [foreign] military control of space as well as its exploitation." As a result, the newspaper reported, the Department had decided that the Air Force would develop the technology for a manned satellite capable of inspecting and destroying a hostile vehicle in space. According to the newspaper, the Department at the urging of both the White House and the Space Council, had undertaken a 6-month study to draft an enlarged military space program. Defense officials were quoted as having said the Department could not rely on NASA exclusively.⁹¹

The circumstances which triggered this story are not fully known. A month earlier Deputy Secretary of Defense Roswell Gilpatric had delivered a speech mentioning the need for taking out military insurance in space. Among the systems under study which he cited was the antisatellite defense system. It was known that the project,

⁹⁰ United Nations General Assembly Resolution 1884 (XVIII), Oct. 17, 1963.

⁹¹ New York Times, June 11, 1962, p. 1.

once called Saint, had at one time or another involved the study of a manned or unmanned device. Mr. Gilpatric referred, however, to something not publicly mentioned before: "The Defense Department," he said, "has decided to develop the technology of manned orbital systems able to rendezvous with satellites and then land at preset locations on earth."⁹²

Such a system also would have the capability of neutralizing or destroying hostile satellites, according to Mr. Gilpatric. Thus the system he projected seemed beyond the Saint guidelines, instead combining Saint with the Dyna-Soar technology. At a press conference later, Mr. Gilpatric indicated that there might be more money in the fiscal year 1964 budget for Defense space projects, but he stated that manned space bombers were not contemplated.

Later in May 1962, the Space Systems Division of the Air Force Systems Command opened negotiations with contractors for a 3-month study of the Saint project. Other than a brief comment in the trade press on this, the growing policy of shrouding all Defense spacework in very tight secrecy prevented anyone from discovering whether major decisions had in fact been made.

At any rate, the public furor that resulted from the June report carried in *The New York Times* was unexpected. The news was immediately interpreted by some as a move on the part of Defense to embark on a man-in-space program which would be in direct competition with NASA efforts. The Defense Department was quick to deny reports that it had decided the Air Force should develop technology for a manned satellite capable of inspecting and destroying hostile satellites. Defense spokesmen would not deny the content of the Gilpatric speech or its accuracy but instead pointed out that no "hard" decision had been made.⁹³

The reaction did not stop there. The Saint contract negotiations reported earlier, were canceled. The Department also had to make public protestations of denial before Congress. Both Deputy Secretary Gilpatric and the Director of Defense Research and Engineering, Dr. Harold Brown, appeared before the Senate Space Committee in June 1962 and denied emphatically that the Defense Department was attempting to preempt NASA's role. Even the policy of developing "building block" insurance came under fire. The chairman of the committee, Senator Robert Kerr, argued that the "building block" policy could be interpreted as a "procedure calculated to, block by block, finally include all * * * systems." Dr. Brown disavowed this intention but explained that basic space technology was required by the Department so that it could move rapidly to take advantage of leadwork if firm requirements suddenly appeared.⁹⁴

Dr. Brown went further in his testimony and thereby cast doubt over not only manned space projects for the military but also the "building blocks" concept. Referring to the subject of military manned systems in space, Dr. Brown said, "I cannot define a military requirement for them. I think there may, in the end, turn out not to be any."⁹⁵

⁹² *New York Times*, June 12, 1962, p. 16; May 13, 1962, p. 59.

⁹³ *Ibid.*

⁹⁴ "NASA Authorization for fiscal year 1963," hearings before Committee on Aeronautical and Space Sciences, U.S. Senate, 87th Cong., 2d sess., June 1962, p. 343.

⁹⁵ *Id.* p. 348.

This statement emphasized the growing policy of restraint on Defense space projects, particularly manned projects. Moreover, having gone on the defensive, the Department was moved further in the direction of reliance on NASA. This was underscored by a remark of President Kennedy at a press conference during the excitement over the *Times* story. When asked whether there would be a bigger military role in space, the President said, "No, the military have an important and significant role, though the prime responsibility is held by NASA and is primarily peace." This remark unfortunately did not help to dispel confusion in the public mind concerning military space activity, which actually was as peaceful as NASA work.⁹⁶

THE SECRECY BAN

Public confusion about military space activities was compounded by the secrecy ban imposed on virtually all such activities. Secretary McNamara, upon entering office in 1961, displayed concern about the publicity given to Defense projects. He subsequently ordered a ban on information about military space programs. This ban was more than an application of normal classification standards. Entire programs ceased to exist as far as public official comment was concerned. Even the secrecy ban itself was hidden from view and Defense officials would neither confirm nor deny the existence of such a ban. It appeared that the reasons for the concealment were more political than military and represented an uneasiness about U.S. reconnaissance activities.

This sensitivity about satellite reconnaissance seemed at variance with official declarations by other elements of the Government that space observation was not a violation of international law. For instance, Leonard C. Meeker, then Deputy Legal Adviser in the State Department, explained in a speech on April 13, 1963, that observation of earth from outer space is "legitimate and permissible activity in the peaceful exploration and use of space. Observation neither works nor threatens injury or damage to any persons or things on earth." To support his point that space satellites are outside the national boundaries of a country's air space, Meeker referred to the weather satellites which also made observations of earth from space. Although the Soviet Union used to criticize regularly both weather and reconnaissance satellites, today such criticism is notable by its absence.

The secrecy ban, however, applied to space activities other than reconnaissance and observation. Removed from the public eye were such projects as the Navy's Transit navigational satellite, the Army Secor geodetic satellite and Air Force scientific satellites. As a result the public was unable to learn much about the military space program despite its success in a broad range of efforts, including in addition to observation and detection systems, navigation, advanced spacecraft techniques, components and materials, communications, reentry vehicles, and even basic scientific discoveries. The trade press continued, however, to report on Defense space activities, and all launches were officially announced. Registration of objects in orbit with the United Nations continued. The door to military space activities was closed after much of the information had been released.

⁹⁶ *New York Times*, June 15, 1962, p. 10.

The ascendancy of NASA in space and the trend toward reliance upon the civilian agency by the Defense Department was made more explicit in criteria established in 1963 by the Secretary of Defense for his approval of Defense space projects. In the section of his posture statement devoted to space, Secretary McNamara stated before the House Armed Services Committee these fundamental criteria for the DOD space program:⁹⁷

First, it must mesh with the efforts of the National Aeronautics and Space Administration in all vital areas * * *. Second, projects supported by the Defense Department must promise, insofar as possible, to enhance our military power and effectiveness.

Requiring such a promise from a research and development proposal and operating under a presumption that NASA came first meant that the Air Force was not likely to meet with success in its desire to give additional emphasis to space activities. In effect, the Air Force was put on what was called by some the "requirements merry-go-round." It wanted to experiment with space systems to enhance its role and to discover what military requirements there might be, but such experimentation was restricted unless it could prove beforehand that hard requirements existed.

MILITARY PARTICIPATION IN NASA PROJECTS

In the meantime, the Department continued to join forces with NASA. On January 21, 1963, NASA and DOD entered into an agreement on mutual participation in the NASA Gemini project. A joint Gemini Program Planning Board was formed to implement the agreement. In May the Board recommended to the heads of NASA and DOD a plan for DOD experiments to be performed on NASA flights. In June the Secretary of Defense approved such a program and directed that the Air Force establish a field office at NASA's Manned Spacecraft Center in Houston, Tex., to manage the integration of DOD experiments into the NASA program. Official recognition was given the decision to rely on the Gemini rendezvous and docking experiments for their possible application to the problems associated with satellite inspection rather than proceeding with advanced development under the old Saint program.

The configuration of the Gemini capsule had been fairly well fixed by the time the agreement was signed, thus making major changes almost impossible. The limited room available in the spacecraft after provision had been made for the primary NASA missions restricted in some measure the value to the military of this joint venture. Nevertheless, it was a useful arrangement that offered a chance, hitherto denied, to conduct basic military experiments in manned space.

The venture proved equally significant to NASA. Among the 16 experiments finally approved for incorporation in Gemini flights, several involved extravehicular maneuvers. These experiments called for the development of chest units and propulsion devices mated to the Gemini space suit. The purpose of the experiments was to demonstrate the ability of man to maneuver and perform useful functions in free space. The incorporation of these devices and

⁹⁷ Hearings on Military Posture, Committee on Armed Services, U.S. House of Representatives, 88th Cong., 1st sess., January-February 1963, p. 483.

experiments took on added importance after the Soviets successfully experimented with extravehicular maneuvers in a manned Voskhod (Sunrise II) spaceship in March 1965.

The other planned DOD Gemini experiments also came to be of importance to later Defense decisions with respect to manned projects, since they helped define such projects and their experiments. For instance, the scheduled DOD Gemini experiments involve photographic and visual definition of terrestrial features and objects in space, navigation measurements, space tools, communications, and spacecraft maneuvering.

Although the Gemini agreement signed by NASA and DOD thwarted the hopes of some military men for a separate military manned program, there was a sidelight which indicated that cooperation need not be dictated on NASA's terms alone. In the last paragraph of the agreement it was stated "that the DOD and NASA will initiate major new programs or projects in the field of manned space flight aimed chiefly at the attainment of experimental or other capabilities in near-earth orbit only by mutual agreement."

A similar provision was incorporated in a later agreement in 1963. In August of that year the two agencies decided to coordinate advanced exploratory studies for a possible new manned earth-orbital R.&D. project. This project, sometimes called a space station, was recognized as the next likely large development program following Apollo and Gemini. The agreement was significant in that it called for cooperation in the planning stage and before any project approval had been granted. Such joint planning anticipated that military as well as other needs would be considered and incorporated before hardware decisions made changes difficult.

Specifically, the agreement provided: (1) advanced exploratory studies on a space station would be coordinated through the Astronautics and Aeronautics Coordinating Board (AACB); (2) upon joint evaluation of the studies, the Secretary of Defense and the Administrator of NASA would make a joint recommendation to the President as to the need for such a project, including a recommendation as to the agency that should direct the project; (3) if the decision were made to proceed with space station development, a joint NASA-DOD board would formulate the detailed objectives and specify the nature of the experiments to be conducted from the station.

MORE REEVALUATION

The space station planning agreement demonstrated that the time was ripe for giving serious attention to the future of the national space program, particularly the manned aspects. The agency planners could begin to look beyond the time when the Apollo lunar mission was completed. This signaled a new and different stage in the reevaluation process. The critical appraisal and refinement of the goals set in 1961 for the space program had occupied the attention of the executive agencies, Congress and informed observers throughout 1963. Changes had been made but the goals were reaffirmed. The Apollo project had gained such momentum by the end of 1963 that there was no chance of turning back. Large sums of money for Apollo had been committed. By the end of fiscal year 1963, \$4.152 billion had been appropriated for the program. Contracts had been

let, installations constructed, and personnel assigned. It remained only to get on with the job and meet the schedule.

In the Defense Department certain projects and systems were achieving operational status, such as those in the areas of reconnaissance, nuclear detection, navigation, ground based antisatellite defense, and over-the-horizon radar detection, but research and development was subjected to major retrenchments, cutbacks and holding actions. In some projects, research and development had reached critical decision points. The question was whether to push development to more advanced or operational stages, continue development at low levels, or cancel projects outright. In this critical category were the Dyna-Soar orbital glider reentry vehicle, satellite inspector, ICBM alarm, and ballistic missile defense.

These projects had been safe in the early stages of research and development when problems had to be investigated and technology developed. Moreover, one could afford a wide array of projects when all could be supported at relatively low costs. When, however, the costs of operating systems, ground support and other required developments had come to demand the larger part of the \$1.5 billion Defense space budget, the exploratory development projects had to justify their existence under rigorous standards. In the case of ICBM alarm, antisatellite and antiballistic missile defense, it was decided finally to reduce the level of effort and postpone more advanced development in favor of ground-based radar and missile defense systems. In the area of communications satellites development was virtually halted pending long discussions over alternative operational systems. In the case of Dyna-Soar and satellite inspection, as in the area of manned space in general, the issue was a mixture of challenged requirements and the competition of the NASA programs.

REQUIREMENTS PARADOX

In NASA the manned programs were absorbing two-thirds of a \$5 billion budget and half of the agency's 34,000 personnel. In the Defense space budget of \$1.6 billion in fiscal year 1964, on the other hand, only \$93.6 million was devoted to manned space flight work. Supporting research and development and general ground and other support were consuming the bulk of Defense's space budget. This presented something of a paradox since a large part of this support was being rendered to the NASA space effort, much of it nonreimbursable. Moreover, the "building block" projects, including the Titan III space booster, were proceeding at a heavy rate of expenditures despite the fact that the blocks had not yet been put together in systems because requirements were still in question.

The nuclear space development effort also suffered from questioned requirements. Here, too, a decision point had been reached on many projects as the issue was debated whether to put the fruits of the research to work or to cancel segments of it. Both the SNAP power units for spacecraft and the Pluto nuclear missile were affected by this requirements analysis. Pluto was finally mothballed, but the SNAP program was given a limited lease on life.

Although the existing situation differed from one agency to the next, generally there was an adjustment downward and a status quo attitude. Many persons began to ask, as they had during a similar

period in 1960, "What next?" In the military field this question was aimed at the initiation of a manned program. With respect to NASA it involved programs to follow Apollo and to exploit its technology.

Again, as in 1960, there were demands and ideas for many different kinds of programs. The scientific community, concerned over the heavy emphasis given to big systems and manned space flight, sought to restore the balance of the early years. Pointing to the gaps still remaining in the knowledge of the nature of space, they asked for more basic research in solar periods, radiation, space biology, and many other areas of scientific concern. Scientists also worried about the techniques of existing research, the drain on resources, and program control by nonscientists. Another school of thought wanted further lunar investigation before pushing on to the planets. Still another wanted more near-Earth experimentation, as with space stations, in contrast to those who wanted a definite timetable set for voyages to Mars or other planets. Most of these demands were directed to NASA. The agency's response was noncommittal. It emphasized that future mission decisions must be made as national rather than solely NASA decisions.

NEW DEFENSE SPACE DECISIONS

In the Defense field the demand was largely confined to the issue of manned space development. The Department seemed to be leaving the initiative to NASA. As noted above, Secretary McNamara had set two rigid criteria for acceptance of new space projects for the military. First, they had to "mesh with the efforts of the National Aeronautics and Space Administration;" and second, they had to "promise * * * to enhance our military power and effectiveness." However sound these principles might be in theory, they effectively barred the initiation of new military manned projects. One after another Air Force proposals were denied or sent back for further analysis either because they had not been defined sufficiently or because they could not "promise" improvements to national security.

Finally, in December of 1963 the Defense Department responded to the demands by taking one step back and another one forward—at least tentatively. On December 10, 1963, Secretary McNamara announced the cancellation of the Dyna-Soar program. At the same time he assigned to the Air Force a new program for the development of a near-earth manned orbiting laboratory (MOL).⁸⁸

The rationale for cancellation of Dyna-Soar was a combination of factors. It was implied that the program was technically overambitious. In effect, the Secretary said that Dyna-Soar had tried to accomplish too many objectives at once—manned space experimentation and precise reentry and landing. As to the first objective, the program could not handle more than one man, said the Secretary, nor provide for extended staytime in orbit, nor lift heavy payloads into space. As to its capability as a vehicle, Secretary McNamara explained that Dyna-Soar was only a developmental program and could not be deployed as a fully maneuverable ferry vehicle in space-earth flights. Moreover, many of the research problems were yet to be solved, and even the development vehicle itself was about 2 years

⁸⁸ DOD press release, 1556-63.

off. These problems were still of interest to the Department, and the Secretary announced the expansion of efforts which used various unmanned configurations to study reentry techniques and materials.

Costs also were heavily emphasized by the Secretary. By the combined moves, the Secretary said, the Department would save approximately \$100 million in 1964-65 space expenditures. Dyna-Soar already had cost \$400 million and was likely, said the Secretary, to reach \$1 billion if allowed to continue.

MANNED ORBITAL LABORATORY

With the MOL the Secretary seemed to have revised his rigid criteria. Heretofore the Air Force had been told, in effect, that there were no requirements or at least only doubtful requirements for a military man in space. At the most, military participation in NASA-directed projects had been approved. The Air Force wanted to experiment, particularly in ways and in areas where NASA had not concentrated, because only then could it find out what the military could do in space and what they might have to do. In short, the Air Force wanted research and development to explore potentials and find out capabilities. Such work could not be initiated on the basis of proving in advance what one was going to discover.

The Secretary in a press conference, held at the time the MOL decision was announced, implied that he accepted this argument:

* * * This is an experimental program, not related to a specific military mission. I have said many times in the past that the potential requirements for manned operations in space for military purposes are not clear. But that, despite the fact they are not clear, we will undertake a carefully controlled program of developing the techniques which would be required were we to ever suddenly be confronted with military mission in space * * *.

The MOL was to be composed of preexisting components, some from NASA's program and others from the military program. MOL was to consist of a modified NASA Gemini capsule as the ferry vehicle and a canister attached to the capsule as the laboratory where two astronauts could move about freely without a space suit and conduct observations and experiments over a period of up to a month in space. Advanced rendezvous, docking and maneuvering techniques were also indicated. The system was to be launched by the DOD-developed Titan III large launch vehicle, thus giving a new use for this biggest of all defense "building blocks" in space. Dyna Soar had been slated for launch by the Titan III. The Secretary was purposely vague about the military experiments to be conducted aboard the laboratory. He mentioned navigation, meteorological "and other classified projects." Obviously, observation, reconnaissance and detection were prime military areas of experimentation but the tight secrecy which shrouds these areas would not permit the Secretary to talk about them.

When asked about the possible duplication with NASA, the Secretary said: "Their program is related to the lunar program * * * they have no near-earth orbit manned operations planned comparable to this." From a broad technological point of view, the MOL would fill

a gap in the national space program by developing a means for testing man's abilities for long duration in near-earth space, including his abilities to work in a condition of weightlessness with machines and instruments. The current NASA projects would not provide this capability. More important, NASA programs were not aimed at particular military objectives. For instance, Gemini was not designed to rendezvous with uncooperative or hostile spacecraft. A military manned orbital laboratory was also necessary as a first step in developing military operational systems in near-earth space. NASA clearly was not concerned with developing systems in that region for reconnaissance, inspection, detection, and so forth.

Nevertheless, the broad, multipurpose aspects of MOL raised the question of NASA concurrence to and participation in the project. The Secretary declared emphatically at the December 1963 press conference that "this entire program will be Air Force managed." Both agencies had agreed to this procedure, said Mr. McNamara:

We are both in agreement that this is a wise move from the the point of view of the Nation * * * and we agreed * * * as we have on the Gemini, that * * * although this project is under Air Force management, we will recognize NASA's request for participation in it to the extent that that does not compromise the Air Force mission, in the same way that Gemini has recognized the Air Force request for piggyback payloads * * * to the extent it doesn't compromise the lunar landing priority and requirement.

At first glance, the MOL decision seemed contrary to the August 1963 space station agreement between NASA and DOD, which required that a joint recommendation on a new manned earth orbital R. & D. project be made to the President by NASA and DOD. In response, officials pointed out that the MOL project was not, strictly speaking, a space station in the sense employed in the September agreement. That agreement referred to a future system "involving spacecraft larger and more sophisticated than Gemini and Apollo" and "capable of prolonged space flight." The MOL was to use the Gemini capsule. Some contended also that MOL would not engage in long flights.

Despite the alleged differences between the MOL and a space station, it was clear that technologically the MOL was to be a kind of space station. That is, it would test out long duration in zero gravity conditions, would be large enough to install equipment other than that needed to get into space and, lastly, would itself be a "building block" toward a larger and more advanced station.

These factors at first were not publicly recognized by either agency. It was assumed that the MOL was essentially a military project to be pursued by the Air Force. As another year passed, however, the MOL, still confined to the study stage, ran full tilt into competition with NASA plans for near-earth orbiting laboratories and stations.

SPACE STATION NEEDS

The need for a space station program had been stated by NASA officials, as well as those in DOD, for some time. Like the Apollo lunar landing project, which had been started in 1961 but long talked about before then, space stations were on the list of every space

planner ever since serious consideration of space exploration began. ARPA had a study program for a station, called Suzanno, in 1958-60. NASA had mentioned it as a potential program in its 10-year plan drawn up in 1960. In fact, some persons then thought it a better step to take in the 1960-70 decade than the Apollo project.

The stated need for a space station was essentially threefold: First, men and equipment had to be tested for long duration in the weightlessness of space, looking toward the time when trips would be taken into outer space and to the planets. Second, a space station would be an ideal scientific laboratory in which to conduct astronomical studies free of the obscurities of the atmosphere, observation of the earth, biomedical experiments, and research into the basic physical and chemical characteristics of matter in space. Third, it would be easier and cheaper to assemble components for launching planetary and celestial voyages in space rather than on the earth. In this last respect, a space station would be a way station to outer space.

These needs envisioned ultimately a large station, composed of many modules or parts, weighing many tons, manned with at least a score of astronauts, and requiring frequent supply and ferry trips. Such a system would be costly and complicated to develop. Many billions of dollars would have to be spent. The time period for such a station was indefinite but usually thought to be sometime in the early 70's. NASA consequently devoted various study efforts, utilizing different centers and industrial contractors, to this ultimate goal. In the meantime, there developed the idea of using approved components in current development to form a preliminary, less sophisticated station, much like the Manned Orbital Laboratory.

Throughout 1964 the Air Force and NASA quietly pursued independent studies of future manned orbital experiments. NASA covered many different concepts, including the more advanced stations, whereas the Air Force concentrated on MOL, the program already assigned it. In what was thought to be the preprogram definition phase of the work, the Air Force contracted for design studies from the major contractors of the Gemini and Titan III systems, which were the announced components of the MOL. At the same time, the Air Force and the Navy contracted for studies on likely experiments to be conducted on board the laboratory. The Navy's interest was in ocean surveillance, both to survey worldwide shipping patterns and to observe foreign military movements at sea. The Air Force also saw need of experiments for observation, detection and reconnaissance, and for learning how men and machine could work together in space. Biomedicine, navigation, rescue, communications, geodesy, and command and control were among the areas of military and technological interest.

The separate NASA and DOD efforts in 1964 appeared to be subject to only a minimum of coordination. There was no indication of joint studies or application of the task force procedures specified in the August 1963 agreement on manned earth orbital research and development projects. Presumably this was considered unnecessary since the agencies had publicly declared earlier that MOL was not covered by this agreement and that, in any case, the MOL was an approved military program of the Air Force, needing no further joint review before contracts were let for hardware development.

By the end of 1964, however, it was obvious to many observers that these separate efforts invited duplication. This issue was raised more sharply when it became known late in the year that NASA was seeking approval of fiscal year 1966 funds for beginning a manned orbital system called Apollo Extended System which would use hardware being developed for the Apollo lunar landing program.

The basic concept could be described as modifying the lunar excursion module and the service module of the Apollo manned system in order to equip them for experimental devices. The command module was to act as the main ferry vehicle in much the same way as the Gemini capsule in MOL. The list of experiments was long, and prime candidates had yet to be selected from the list, but the areas of major interest were the space sciences, earth-oriented applications, and space operations support.

Major questions left unanswered were those of cost and timing. Nevertheless, it was believed possible to have up to a score of flights in the late 1960's, accommodating different sets of experiments and kinds of orbit and using varied configurations and subsystem components.

The Air Force by late 1964 had estimated six flight missions of the MOL in a program costing approximately \$1 billion. The schedule was uncertain since it depended on firm program go-ahead, but 1967 was the target date of Air Force planners.

DEMANDS FOR COORDINATION

The apparent overlap of these plans created new demands for coordination. Uncertainty developed about the future of MOL, as some advocates proposed merger of the two planned projects, others a joint program, while still others wanted the MOL project canceled. Reports from the Pentagon were vague as this debate proceeded. In December 1964 it was reported that the Administration had decided to delay construction of the MOL while it attempted to mesh the military and civilian plans.⁹⁹

Official silence was broken in January 1965, when final touches were put on the budget proposals for fiscal year 1966 funds. A year after the cancellation of Dyna-Soar and the assignment of MOL, the Secretary of Defense once more announced new decisions. The Administrator of NASA did likewise. They were contained in a joint statement released by both NASA and the Defense Department.¹⁰⁰

First of all, the Secretary had broadened the MOL program guidelines to accentuate eventual operational systems. New experiments were approved involving the construction of big antennas and optical equipment. Department spokesmen later confirmed that this meant increased attention to observation missions for the MOL.¹⁰¹ Experiments aimed at investigating man's usefulness in space had dropped to last place in the list of program objectives.

At the same time the Secretary announced that the Department would study the possibility of using Apollo hardware instead of the Gemini equipment. A study of potential NASA experiments also

⁹⁹ New York Times, Dec. 20, 1964, p. 45.

¹⁰⁰ DOD press release No. 42-65, including NASA-DOD decisions released Jan. 25, 1965.

¹⁰¹ Statement by Dr. Harold Brown before the Committee on Armed Services, U.S. House of Representatives, Feb. 25, 1965, p. 17.

would be made in order to determine the feasibility of their incorporation into a military program.

A cooperative arrangement to exchange study information and ideas was made between NASA and DOD. Upon the completion of the study effort, sometime in late spring, 1965, a decision would be made, according to Secretary McNamara, whether or not to proceed with full-scale development of the MOL.

To provide sufficient leadtime, however, the Secretary also announced that part of the \$150 million he was requesting of Congress would be applied to doing preliminary work on Titan III and Gemini capsules and conducting unmanned test launches, using boosters in the approved Titan III development program. The rest of the funds would be spent on study contracts. The study contractors, in what was once again described as preprogram definition, would be the later competitors for the actual development program.

NASA, for its part, announced it would continue studies of modifications to the Apollo system. The major objective was extension of astronaut staytime on the moon. Other objectives also would be studied, but the agency emphasized that the lunar program continued to have top priority. Future decisions with respect to a follow-on manned NASA program depended upon the following factors: the MOL final decision, the progress of the Gemini and Apollo programs, and the results of the studies. In the meantime the NASA budget request for fiscal year 1966 included \$50 million for study contracts and lead-item development of the Apollo extended system.

VII. CIVIL-MILITARY COORDINATING MECHANISMS

The problem of achieving close interagency coordination and the need for eliminating unwarranted duplication, illustrated by the orbital laboratory case, increasingly have become matters of concern. These matters have undergone the same process of reevaluation as have questions of program initiation and management. Such reevaluation has been made necessary by the high costs of the space program and the proliferation of broad, similar technological efforts in each agency. In part, there has been an interaction between cooperation and competition. For instance, the Air Force has been tasked by Defense Department directives to be the prime moving force for a military space program and also to be the major supporting element of the Department for the civilian program.

ELEMENTS OF COOPERATION

Ways and means to resolve the problems arising between the two major agencies engaged in space activities are many and complex. Some are initiated by top management in each agency, leading often to formal NASA-DOD agreements, signed by the two agency heads, which operate almost like treaties between sovereigns. About 90 such agreements have been signed to date.¹⁰² Coordination at the top also takes place through the auspices of the Aeronautics and Astronautics Coordinating Board (AACB), established in late 1960 in place of the dormant Civil-Military Liaison Committee provided by the Space Act of 1958. The AACB presently is cochaired by the Associate Administrator of NASA and the Director of Defense Research and Engineering. Various panels and subpanels of the Board work on specific program areas of mutual concern and are composed of representatives from the headquarters offices of the two agencies. The AACB has been an effective forum, particularly for exchanging ideas and airing problems. The Board has no decisionmaking powers; its effectiveness relies instead on the expectation that when problems are exposed, each side will make the proper decisions to solve them.

Similarly, many of the day-to-day working relations of the two agencies must depend on people in the field working out the difficulties they encounter. These expectations do not always assure results. Personnel in the field may be able to recognize issues but do not have the sufficient authority to resolve them, creating demands on headquarters management. At that level, too, the agencies have sometimes shown themselves, particularly at the middle or program office echelon, unwilling to grapple with problems or even unaware of their existence. In such cases, the intervention of other offices of Government is required, either by the Congress or by the President and the elements of his Executive Office, such as the Space Council, the Office of Science and Technology, and the Budget Bureau.

¹⁰² See appendix D of this report, p. 123.

Another element of cooperation is self-generated by the complex interrelationships growing out of an area of Government activity shared for the most part by two agencies, NASA and the Defense Department. As these two agencies have become heavily involved in similar technological problems and projects, inevitably they have been thrown together. This similarity of interests has created various cooperative arrangements in the form of joint projects, reliance on each other's hardware and support facilities, and common management and procurement procedures.

This interrelationship is associated with a common industrial base. Illustrative is the fact that 40 of the top 100 NASA contractors are also among the top 100 contractors for experimental, developmental, test, and research work in the Department of Defense. A more striking statistic is that among the top 10 of these contractors, 5 are the same on both lists: North American Aviation, Boeing, General Dynamics, General Electric, and Aerojet General. Of the top 25 in both lists, 14 are the same. In short, what has been called the aerospace industry serves both NASA and DOD in spacecraft, propulsion, electronics, engineering, and subsystem components.¹⁰³

Achieving uniformity to exploit the similarity of interests, however does not come automatically. The inclination to create separate management procedures is as strong as the desire to build separate facilities and support organizations. There is no formal coordinating body, comparable to the AACB, to tackle mutual management and procurement problems. Complete uniformity is both impracticable and unwise. Nevertheless, each agency has sought with varying results to learn from and use the practices of the other. At first, NASA used the Armed Services Procurement Regulations, but after developing its own experience and separate needs, the agency instituted independent procurement regulations. Although the NASA regulations follow in many major aspects the Defense regulations, a NASA representative sits only as an interested observer and consultant on the Armed Services Procurement Committee. The Armed Services Procurement Act, however, still applies to NASA.

Both agencies have adopted a common "program review evaluation techniques," or PERT cost, manual. In addition, NASA uses the Defense Department industrial security program and relies on Defense contract administration services in many instances. NASA also contracts for about 20 percent of its procurement dollar with or through the Department of Defense. The two agencies have explored the possibility of a common contractor performance evaluation system, similar to that being studied by the Defense Department. DOD has looked with interest at NASA's source selection methods. Firm decisions in these and other promising areas, however, have yet to be made.

A significant new management practice was instituted in October 1964 when the two agencies agreed on a single system of reporting and exchanging research and technology information. The new standard reporting form is designed for internal as well as external use. The agencies hope that this system will give the managers of laboratories

¹⁰³ "NASA Annual Procurement Report, Fiscal Year 1964," table VI, p. 4-14; Office of the Secretary of Defense, 500 contractors listed according to net value of military prime contract awards for experimental developmental, test, and research work, fiscal year 1964.

and centers an up-to-date detailed picture of the total NASA and DOD programs so that they can select their own programs with a full understanding of how they relate to similar work in the other agency's organization.

Program planning cooperation also is generated by the requirement for mutual study and approval before certain kinds of major programs are initiated. This requirement was embodied in the Gemini, space station, and large launch vehicle agreements. These agreements call for close working relationships at the concept stage of a program rather than after configurations have been fixed. Implementation of these requirements, however, has met with varying degrees of success, as the orbital laboratory problem demonstrates. It is not enough for each agency to exchange information at the program office level. The information must be worked over by field offices in each agency, and action must be taken and decisions made at the top management level.

Close relationships were furthered by yet another practice, increasingly evident between 1963 and 1965, transferring military personnel to posts within NASA. In 1963 there were 150 active-duty military officers working full time at NASA offices and centers. By early 1965 the number had grown to 266, of whom 120 came from the Air Force, 105 from the Army, and 39 from the Navy and Marine Corps. Retired military personnel also were given jobs at NASA.

This practice demonstrated the values of interdependence. NASA needed trained personnel experienced in systems and project management. The programs of the Defense Department developed such competence. On the other hand, the transfer was a good way for the military to learn more about NASA and space work and thus be able later, when they returned to the services, to deal with the civilian agency and space problems on a better basis of understanding.

A number of former or active-duty military personnel assigned to NASA held key, critical posts. For example, in 1962 Admiral W. F. Boone, U.S. Navy (retired), was named to the newly created post of Deputy Associate Administrator for Defense Affairs, responsible for liaison between NASA and DOD. In late 1963 an Air Force general, experienced in the Air Force Minuteman missile program, Brig. Gen. Samuel C. Phillips, was put in charge of management and administration of Apollo, reporting directly to the NASA Associate Administrator for Manned Space Flight, Dr. George Mueller. In 1964 two other Air Force generals, one on active duty and the other retired, were appointed to NASA posts. Brig. Gen. David M. Jones was named Deputy Associate Administrator for Manned Space Flight and Lt. Gen. Frank A. Bogart (retired) became special assistant to Dr. Mueller.

Other military officers holding top NASA jobs include Vice Adm. Rufus E. Rose, Special Assistant to the Administrator, and Lt. Col. Rocco Petrone, U.S. Army, Assistant Director of the Cape Kennedy Space Center.

By an agreement signed on September 25, 1964, NASA now has an opportunity to assign its personnel for duty in the Defense Department. The agreement provides for the detail of NASA employees to the Air Force in positions which will give them experience of benefit to NASA when they return.

COORDINATION DIFFICULTIES

One of the difficult areas of coordination relates to launch, range, and tracking facilities. A mixed pattern of separate and shared facilities in range and tracking operations developed from the first days of the new space agency. NASA has used both DOD launch vehicles and launch facilities. This was to be expected, since many space boosters were modified military missiles or were Defense-developed vehicles. To support the missile testing program and the early space projects, the Department had built up a multibillion dollar complex of launch stands, range stations, and tracking facilities, located on the Atlantic and Pacific coasts and in distant areas. As the program grew there remained for some time a multipurpose launch and range complex serving all agencies as a national asset, but unique requirements of tracking, command and control, and data acquisition for much of the space program led to the establishment of NASA facilities separate from the missile program or from the Defense Department at large. NASA acquired from the Defense Department and then expanded the original Minitrack tracking net for satellites and the deep space net used by the Jet Propulsion Laboratory for moon and other space probes. The Department of Defense also built new and separate facilities for some of its satellite and space programs. The two agencies, however, continued to use both networks and facilities where cross-servicing was possible. The resulting situation was often a confusing one to understand and to work with. More centralized management and uniformity were needed but made difficult by the demands of unique program and agency requirements, heavy workloads, and the maze of jurisdictional lines between and within agencies.

In the area of launch and range support, centralized management by the Defense Department on behalf of all users continued to be maintained up to 1961. NASA paid directly or reimbursed the Defense Department for launch vehicles and actual launches which took place on Defense property at Cape Canaveral or the Pacific range. Range services and some other support were provided largely without reimbursement by the military services.

CHANGING RANGE RESPONSIBILITIES

It was assumed at first that this pattern would continue after the Apollo decision, particularly since a joint study resulted in the selection of the Cape Canaveral, Florida, area as the site for the launching of Saturn vehicles in the Apollo program. Vast new tracts of land, however, had to be acquired for the Saturn test stands and other support facilities. This resulted in the first variation from the existing pattern.

In an agreement signed on August 24, 1961, by Deputy Defense Secretary Roswell Gilpatric and NASA Administrator James Webb, it was decided that NASA would seek appropriations for the new land acquisition as well as for the facilities and improvements on the land. At the same time it was agreed that the new launch site would be operated as a joint DOD-NASA venture under single management "in order to prevent duplication and promote efficiency." Single management was decreed. Primary Defense responsibility in this respect was implied by the provisions of the agreement. Although by its terms NASA was made responsible for the design, construction

and operation of all mission facilities and equipment for NASA programs, DOD, as agent for NASA, was to prepare the master plan for all facilities, design and accomplish the construction work, and design and procure all range support equipment. The Air Force was made responsible for all range operations. Under prior definitions of the term "range," this implied an extension of the Atlantic Missile Range procedures, also under the control of the Air Force, for the benefit of all users. This pattern meant that the Air Force would have ultimate responsibility for property, operations management, and support. NASA, however, was given custody and control of its own unique equipment, as well as associated responsibility for launch and checkout.

After further review of the question by Congress and top agency officials, it was decided that separate rather than central management would exist at the new site. Part of the rationale for this change stemmed from a decision that since NASA was paying for the new land it ought also to manage the property.

In the meantime another factor entered the situation. With the initiation of the Defense Department's Titan III large launch vehicle program, there was a need on the part of DOD as well as NASA for new launch sites near Cape Canaveral. Discussions in 1962, therefore, involved both the question of where launch stands should be located and the question of which agency would manage the new property.

On January 17, 1963, a new agreement was made between NASA and DOD. Under its terms a separate tract of land, consisting of 87,000 acres of land north and west of Cape Canaveral, was recognized as the Merritt Island Launch Area (MILA), to be owned and managed solely by NASA. Excluded from this area was the site for the Titan III launch facilities. Another distinct operation and tract of property was identified as the Atlantic Missile Range (AMR), owned and administered by the Air Force Missile Test Center. This consisted of the property and facilities of Cape Canaveral, Patrick Air Force Base, the downrange island instrumentation stations, and other support sites in the United States.

Although "range" under this agreement meant property and facilities as in the old agreement, only DOD property and operations were to be managed by the Air Force. The term "range" also was used to indicate that DOD would continue to have a supporting role for NASA as well as DOD launches. In this other sense, range functions were defined as essentially those support services rendered to the mission after launch. They included tracking and other instrumentation support from the down-range stations in the Caribbean, South Atlantic Ocean and Africa, flight safety, frequency control, search and sea recovery, airlift, and scheduling.

Other than this mutual support under single management, each agency was responsible for its own property areas. This individual responsibility included general housekeeping functions such as property management, maintenance, water, fire protection, and security. At MILA, contrary to the previous agreement of 1961, NASA was made responsible for master planning and development of its own land and facilities. In addition, each agency, regardless of location, was responsible for preparation, checkout, launch, and test evaluation of its own flight missions.

Recognizing that this new arrangement carried the danger of creating undesirable duplication and unwarranted departures from standardization, the agreeing parties called for full and early consultation between the AMR and MILA. No specific consultation procedures, however, were prescribed.

TRACKING SHIP PROBLEM

The tracking function also required outside intervention in 1963. NASA submitted a request to Congress for \$90 million for the conversion of three ships from the maritime reserve to perform tracking, command, and data acquisition functions for the Apollo lunar program. The proposal specified that these ships were to be obtained, modified and operated by NASA rather than by the Defense Department, which had charge of the existing tracking fleet.

During the review of the fiscal year 1964 authorization request, testimony revealed that NASA requirements were formulated independently of DOD plans for more tracking ships. Consequently, the Congress directed the two agencies to undertake a joint study and arrive at an agreement that would result in a pooling of tracking ship resources.

The two agencies formed a special committee of the Aeronautics and Astronautics Coordinating Board (AACB). The efforts of this committee resulted in a decision to pool instrumentation ship resources. The committee findings stated that by so doing a substantial capital investment savings could be realized.

Under the terms of an agreement effected on January 14, 1964, the Defense Department was made responsible for the management of all instrumentation ships in the inventory, obtaining custody and accountability as well as operational responsibility for the ships. The Air Force was given centralized planning, scheduling, and management duties, subject to the requirements laid down by NASA and DOD for ship support. It was further agreed that Apollo requirements when stated by NASA would receive top priority.

The job of selecting, designing, and modifying the ships in the pool was delegated through the Navy to a special Instrumentation Ship Project Office with representatives of the Air Force, NASA and Navy attached to it. Responsibility for maritime operation of the ships was placed in the Navy's Military Sea Transportation Service (MSTS), which was the existing pattern for instrumentation ships of the DOD Pacific Missile Range.

The agreement also stated that the Defense Department would provide the technical crews for operation and maintenance of the instrumentation on all ships in the inventory, but in the case of ships assigned for support of NASA programs, the crews would be trained in accordance with standards set down by NASA.

This arrangement set a precedent for future consolidation and standardization of DOD and NASA instrumentation services. In late 1964 actions were begun to develop a national instrumentation aircraft fleet for support of NASA's Apollo program and DOD missile and space missions. Problems in this functional area, however, persisted, requiring a case-by-case process of lengthy negotiations in the absence of general policies and complete coordination in the planning stage. For instance, when NASA sought funds for a new tracking facility for

the Apollo program on Antigua Island where Defense range facilities already existed, the Congress had to intervene once more to insure that economies would be achieved through single management and closer coordination.

A completely integrated, multipurpose launch, range, and tracking organization run by one agency for all space users is now difficult to create. Unique missions and heavy schedules dictate the continuation of some separate facilities and organizations. Despite this fact of life, the agencies must continue to work toward standardization, cross servicing and more integrated management and planning. At sites where both agencies have needs single management should be the rule.

In the Defense Department, a measure of centralization was achieved when part of the Navy's Pacific Missile Range was transferred to the Air Force, which established a National Range Division within the Systems Command to plan for and manage the operations of the Eastern and Western Test Ranges. The Commander of this Division, Lt. Gen. Leighton Davis, also was given unified command, under the Joint Chiefs of Staff, for all Defense resources in support of NASA manned space operational flights, continuing the role he played as DOD Representative in Project Mercury.

The only place where all Defense range and tracking problems can be tackled together is in the Directorate of Defense Research and Engineering, where an Assistant Director for Ranges and Space Ground Support with a small staff exercises staff and review functions.

NASA has appointed a Mission Operations Director to provide for central operational responsibility in manned projects and a single point of contact with DOD, assisted by an Operations Support Requirements Office. This will require working out a new relationship with the separate NASA Office of Tracking and Data Acquisition. Although mission directors will continue to demand that support facilities meet their program requirements, the need for a multipurpose, standardized support base, as in tracking, which can serve many mission programs has to be asserted and implemented vigorously. Otherwise, expensive, single-purpose facilities will be created for each program or mission.

The relationship between mission and support always has caused difficulties for both agencies. At one time, the functions served by the present NASA Office of Tracking and Data Acquisition were lodged in the Launch Vehicle Office, and before the present office was created, thought was given to placing it in the Office of Manned Space Flight. A similar problem exists in the Defense Department where the Satellite Control Facility reports only to the management of the classified space projects, an arrangement at variance with the new National Range Division.

WORKING-LEVEL COORDINATION

These agreements required a high degree of coordination at the working level of the two agencies. Some notable successes have been achieved in this regard although rarely without the demonstration of concern by top management or the Congress. One mechanism for higher level coordination is the AACB. An example of the close degree of collaboration that can be attained by the two agencies was provided by the work of a subpanel of the AACB's Supporting Space

Research and Technology Panel. The subpanel, chaired by Dr. Eugene B. Konecci, now of the Space Council staff, concentrated its attention in 1963 on the job of eliminating duplication and providing for a crossflow of information in the area of life sciences. To accomplish this task individual project officers on the working level exchanged data cards on all of the 2,700 separate tasks involved in life sciences.

After the data cards were collected, they were distributed for comment to members of the subpanel, which included representatives of each of the military services as well as DDR&E and NASA. The results of this study resulted in the cancellation of some projects and in increased funding or reorientation of others. As an important byproduct of this effort, the several agency representatives gained valuable information about their mutual field of interest. Moreover, machinery was instituted to continue the evaluation process in the future. An existing data system was selected to abstract and collate relevant data on life science projects. Filed in the data bank was information on each project describing the particular project, the organization doing the work, the scientists and officials involved, and pertinent contract provisions. This automated system was used to coordinate over 4,000 NASA and DOD tasks in 1964 and was also used as a model to establish a method for exchange and coordination of all NASA and DOD supporting research and technology programs, mentioned above. At least 40,000 tasks are estimated in these programs.

A similar process of review and analysis was conducted in 1963 on all space medicine projects in NASA and DOD. In this field, since many of the space medicine and bioastronautics projects were directly linked with approved flight programs carrying definite time deadlines, the evaluators first attempted to see if the projects were in fact realistically time-phased with the schedules of the programs they were supporting. The evaluators also sought to modify the projects and supporting contracts where economically feasible in order to meet the technical requirements of both agencies and to insure maximum use of facilities.

In this review, duplication was permitted if the research problems demanded more than one approach, if there was a scarcity of support in the particular problem area, or if it was necessary for maintaining "in-house" capability.

As a result of the review of 900 space medicine tasks, 335 were found to be on sound ground, 55 were canceled, 2 were assigned further examination, and 488 were considered outside the scope of mutual interagency decision since they were necessary to the peculiar needs of the respective agency. In aerospace medicine, the Air Force continues to carry the major burden of the work for both agency requirements. The Air Force conducts 718 such projects and NASA 119.¹⁰⁴

It was appropriate to leave much of the coordination to the working level because formal mechanisms, headquarters intervention, and interagency treaties had definite limitations. Time was scarce for such procedures, and there was no assurance that top-level review could tackle all the problems. In fact, by 1964 there were

¹⁰⁴ "The NASA-DOD Relationship," report of the Subcommittee on NASA Oversight, Committee on Science and Astronautics, U.S. House of Representatives, 88th Cong., 2d sess., 1964, p. 5.

indications that coordination itself had become topheavy and overly complicated. NASA, at the headquarters level alone, was involved in 203 interagency coordination and advisory bodies. The Defense Department was often the other partner in these bodies. The Air Force also worked through different committees and interagency groups. In the areas of life sciences, materials, and environmental sciences alone, the Air Force was represented on 47 such bodies.

REIMBURSEMENT ARRANGEMENTS

Reimbursement for the many cooperative arrangements between NASA and DOD also is a subject of continuing concern. The Space Act of 1958, as amended, in section 203(b)(6) authorizes NASA to use, with their consent, the services, equipment, personnel, and facilities of other Federal agencies with or without reimbursement. The same section also authorizes any department or agency to transfer to or to receive from NASA, without reimbursement, aeronautical and space vehicles, and supplies and equipment other than administrative supplies or equipment. This language neither requires nor forbids reimbursement and leaves to the agencies specific reimbursement arrangements and policies.

The only general NASA-DOD reimbursement agreement in existence dates back to November 1959. Since then exceptions and additions have been engrafted upon the general principles embodied in that agreement. The 1959 agreement provides the following: When either agency places a contract through the other, reimbursement is limited to direct costs; when DOD performs an "in-house order" for NASA in facilities using an industrial-type cost accounting system, the billing basis is the same used for all customers of the Government, and if such a system is not used, only direct costs are charged; when either assigns a contract to the other for administration, the direct costs involved are reimbursable; when either provides the other with materials, supplies, or equipment, reimbursement is in accordance with established agency pricing practice, but DOD may loan equipment to NASA without charge; construction undertaken by DOD for NASA is charged directly to NASA funds; when either agency is a tenant on an installation of the other, all direct costs attributable to such tenancy are reimbursed, but rent or depreciation are not charged for the use of each other's facilities.

These principles do not by themselves resolve each specific situation to which they apply, and, moreover, they do not apply to all cases. For instance, when functions are performed by one agency in support of the work of both agencies, reimbursement may be limited to tasks performed only for the other agency, but it is often difficult to estimate such costs. In a current situation, the agencies are negotiating the question of centralizing supply services at Cape Kennedy, Fla., where both NASA and the Air Force Eastern Test Range are located. The aim is single management to achieve economies and eliminate duplication, but it is still an open question as to what means of reimbursement will be arranged. On the other hand, the actual operations of the Defense ranges in support of NASA flight missions usually are not reimbursed at present, although certain logistics, materiel, and construction services are.

The DOD-NASA agreement of January 17, 1963, provided that both agencies would undertake a joint study to determine whether NASA should pay a pro rata share of the costs of the Atlantic Missile Range based on the relationship of NASA program workload to total range workload. In December 1963, however, it was decided to continue the existing funding arrangements.

When standardized space boosters are developed by one agency, the other user agency does not normally pay for development costs and instead pays only for the production item. Again, there are exceptions. Although NASA paid for production and procurement costs of the Titan II Gemini launch vehicle, some modification costs were borne by the original developing agency, the Air Force. On the other hand, when a weight reduction was required for the Agena D vehicle, NASA and the Air Force shared costs equally. In the case of programs of use to both agencies, usually there is little reimbursement involved in the transfer of data or the support services provided, as, for instance, in the communications, weather, and geodetic satellite programs. By contrast, NASA is funding the gravity gradient experiments to be conducted in the initial defense communications satellite program.

Another change made in the 1959 reimbursement principles has taken place in the area of contract administration. In the 1959 agreement a permissive standard was established whereby the administering agency could be reimbursed to the extent of special direct costs. In the intervening years the Army and the Navy made separate agreements providing for reimbursement for actual man-hours expended in support of NASA contracts. In June of 1964 the Air Force also obtained a larger degree of reimbursement for industrial facilities and contract management support of NASA.

NASA now relies almost completely on the Defense Department for contract administration, except for maintaining separate factory representation in plants working on major parts of the Apollo program. In April 1964, NASA agreed to participate in the pilot project in the Philadelphia region aimed toward a new consolidated Defense Department contract administration service, and with the establishment of this service under the Defense Supply Agency, the two agencies are now negotiating a comprehensive arrangement for such activities, including preaward surveys, price and cost analyses, negotiations assistance, quality inspection, plant representation and property administration. NASA continues to have technical direction of its projects. In the pilot project arrangement, both direct and indirect costs are subject to reimbursement on a cost-per-hour basis.

PROS AND CONS OF JOINT PROJECTS

Another coordinating device which has advantages as well as limitations is joint project management. The classic example of a sound and mutually beneficial joint project is the X-15 hypersonic research aircraft project, initiated under the original NACA-DOD X-series aircraft program and still flourishing under an agreement between DOD and NASA.

A joint program has some built-in advantages for insuring coordination and eliminating duplication. There are, however, different kinds of joint projects with varying degrees of efficacy in performance.

At one extreme is joint project direction, illustrated by the nuclear rocket program, Rover. The Atomic Energy Commission has the primary responsibility in this program for the nuclear reactor research and engineering and NASA is responsible for the nonreactor components of the system. NASA also is charged with the task of combining the reactor and other components into engine systems and with developing the flight vehicle. AEC and NASA have established a joint Space Nuclear Propulsion Office to manage this program.

At the other extreme are projects in which one agency has all of the management and decision making authority and does most of the work, while another agency acts essentially as subcontractor for remaining portions of the work, responsive to the requirements and direction of the managing agency. The Defense ground support functions in Mercury and Gemini can be classed in this category. NASA also has procured various pieces of hardware through Defense Department contracting agencies. Similarly, NASA has tasked the Army Corps of Engineers with the job of building many of the agency's new facilities. Conversely, the military services have relied upon NASA wind tunnels and laboratories to perform research and design tasks in support of DOD-developed projects.

In the middle of the spectrum are programs whose success is dependent on the functioning of separate, co-operating systems. For example, NASA's synchronous communications satellite program (Syncom) used NASA-developed spacecraft and Army-developed surface terminals and tracking stations. These stations had been built under the separate Defense communications satellite program. In another example NASA has used boosters developed by the military services for launching NASA payloads.

The Gemini program is an example of a program that became more of a joint program as it proceeded. Although Gemini, using DOD-developed boosters, was assigned to NASA for sole management, military experiments have been mated with NASA experiments in a later stage, and, as noted previously, this has resulted in mutual advantage to both NASA and DOD. Nevertheless, since the NASA mission requirements dominated, and the capsule configuration and the guidelines of the entire project were fixed before DOD participation began, it was not possible for the military to achieve all its objectives in manned space flight by such participation. Consequently, the Gemini capsule is to be modified and mated with a new cannister for the MOL program run by the Air Force, when and if the original MOL plan is allowed to go ahead.

PRESERVING UNIQUE AGENCY NEEDS

Even projects joined at the outset have their limitations. For one thing, compromises must be worked out to meld different and often conflicting requirements. Secondly, there may be unique agency methods and techniques of development and operation required by different mission needs of each agency despite technological similarity in a general field of activity. For instance, the Titan III will be a standardized launch vehicle for use by both agencies, but it is also expected to meet particular military requirements, such as quick reaction, low-cost launching, long duration storability, rapid transportability, repeated operations, and assured reliability.

Another weakness of a joint project is the dispersion of authority and responsibility. There is a temptation in joint projects for one agency to save money in an area where it does not have a great priority or need. If an agency regards its share of the work as merely a service for another agency, or if full agency prestige is not on the line, support tends to diminish. "Buckpassing" develops. These potential weaknesses are not limited to joint projects between agencies but also to those carried on within agencies.

The split responsibility between Defense-civil agencies, the Air Force, the Army, and NASA in the Advent military communications satellite project contributed to the troubles and later demise of that project. Similar difficulties plagued the Scout program before complete standardization and single management were provided.

When two agencies have joint direction of a project, as in the Rover nuclear propulsion program, they often cannot agree on requirements and the pace of the program. The cancellation of the RIFT vehicle component and the delays in the NERVA portion of the Rover program are due in some measure to such disagreement.

A particularly baffling joint effort has been the geodetic satellite program. The field of geodesy itself is difficult for the layman to grasp. The satellite program often has been inaccurately referred to as a mapping system. Actually, geodesy itself is a branch of mathematics, and the geodetic satellite is used to derive basic mathematical information about the position of points on the surface of the earth; the shape, size, and the mass distribution of the earth; and the earth's gravitational field.¹⁰⁵ Such information is helpful for mapping, but the satellite does not accomplish the mapping. Geodetic information is, however, necessary for other practical applications. Foremost of these for space activities is the determination of the accuracy required for the flight path and impact point of vehicles that are launched from earth and pass through the atmosphere or space. Accuracy for ballistic missiles is the primary military requirement for such information. For NASA the basic requirement for a geodetic satellite stems from the needs of mathematicians and scientists in the technical community. In addition, both NASA and DOD will improve tracking operations by information gained from geodetic satellites.

NASA and DOD have been interested in geodetic satellites since the outset of the space program. In the early years feasibility studies were conducted by the Air Force and the Navy. In 1959 NASA prepared satellite specifications to meet the needs of the military and those of the international geodetic community. In the middle of the following year the Department of Defense recommended that the data obtained from the satellite program be classified because of fear that data from the satellite might furnish a potential enemy with valuable targeting information. This recommendation was accepted by the AACB, and NASA canceled plans for its project because it did not want to participate in a classified venture.

The Department of Defense subsequently undertook a program, called ANNA, an acronym representing the participation of the Army, Navy, NASA, and the Air Force. Again, due to the classification issue, NASA's participation did not materialize. The overall direction of the project, which began in January 1961, was assigned

¹⁰⁵ Project ANNA-geodetic satellite system, report of the Committee on Science and Astronautics, U.S. House of Representatives, 87th Cong., 2d sess., H. Rept. No. 2151, Aug. 8, 1962.

to the Bureau of Naval Weapons in the Navy. Technical direction and the responsibility for developing the satellite were given to the Applied Physics Laboratory of the Johns Hopkins University. The ANNA satellite was to consist of three separate systems developed independently by the three military services. The Navy system employed the principle of radio doppler, such as used in the Navy's navigational satellite. The Army system used a radio ranging transponder called Secor, standing for sequential collation of range. The Air Force system used a high intensity flashing light or optical beacon. The satellite ANNA 1B was launched on October 31, 1962, and is still furnishing geodetic data. The Secor transponder has been inoperative since its launch, and the beacon light failed for 6 months.

A review of the project in 1962 led to its declassification following a decision in D.D.R. & E. that the risks of providing valuable information to a potential enemy were acceptable. An agreement signed in December 1962 transferred overall project direction for a follow-on geodetic satellite program to NASA. The Defense Department retained responsibility for ground tracking stations and preliminary processing of data. At this point NASA had not stated definitive requirements for the satellite, and no firm plan for a system was available. It was not until late 1963 that the emergence of new military requirements calling for an immediate launch schedule spurred the development of program plans.

A further understanding reached in October 1964 between NASA and DOD established a new national program for satellite geodesy. In the meantime, the Department of Defense began a series of Secor launches. As the first phase of the joint program, which had as participants NASA, DOD, and the Coast and Geodetic Survey of the Department of Commerce, an Explorer Beacon satellite was launched by NASA in October 1964. The program calls for future launchings of Beacon Explorers; second-generation ANNA-type satellites using Secor, doppler, and beacon systems; and a passive sphere called Pageos with a reflective surface like the Echo communications satellite, which has also been used in the interim for geodetic purposes.

The new program is a technically sound one, but its organization and policy guidelines remain confused. The issue of classification is still unsettled; some geodetic efforts are not directly tied to the new program; and there is considerable uncertainty about international participation, particularly on the part of the Soviet Union.

The problems of effecting close interagency coordination and of eliminating undesirable duplication cannot and have not been solved solely through the efforts of the separate agencies involved in the space program. Even top-level attention in the agencies will not suffice, whether it takes the form of agreements signed by department heads or deliberations of the AACB. Such groups do not have enough time to explore or resolve all the problems that arise. Moreover, disagreement at the top is no less likely than disagreement at the bottom.

Consequently, outside intervention has been required from time to time. This has come from Congress and from the Executive Office of the President. In the latter category there are several bodies with advisory or directive authority, such as the National Aeronautics and Space Council, the Bureau of the Budget, the Office of Science and Technology, and various special assistants to the President. Since

the Budget Bureau holds the purse strings, its role can be particularly effective in resolving disputes and checking unwarranted duplication. Within the Bureau the Military Division is responsible for budget analysis of the Defense Department, NASA and AEC. Forty-three professional staff members work in the division, only three of whom work on NASA matters. Consequently, an overall review of most Government space activities is possible, but the emphasis on funding questions leaves limited time for resolving coordination and duplication issues.

THE SPACE COUNCIL

The Space Council is one of two statutory coordinating bodies provided by act of Congress. The other body, the Civilian-Military Liaison Committee, is now defunct. The Space Council is composed of the Vice President as Chairman, the Secretary of Defense, the Secretary of State, the Administrator of NASA, and the Chairman of the Atomic Energy Commission. The Council has a staff headed by an executive secretary, appointed by the President with the advice and consent of the Senate.

The authority of the Space Council is set forth in section 201(e) of the Space Act, as amended:¹⁰⁶

It shall be the function of the Council to advise and assist the President, as he may request, with respect to the performance of functions in the aeronautics and space field * * *.

The Congress in providing for the Space Council adopted the basic assumption that coordination of several agencies engaged in related pursuits requires centralized planning, guidance, and authority to make decisions which are binding on all concerned.¹⁰⁷ The Congress intended that the Space Council, acting as an arm of the President, would have authority to resolve interagency problems and responsibilities. The Senate Special Committee on Space and Astronautics indicated this intention:¹⁰⁸

The Space Council * * * has the advantages of centering responsibility in accordance with a statement of the overall problem which requires solution * * * establishing a recognized procedure for considering the views of affected Government agencies whose directors might otherwise appeal, or fail to appeal, to the President concerning new programs or gaps in the existing plans. The special committee could not be certain that the entire U.S. space program, including defense and civilian activities, would be effectively planned and coordinated unless some formal type of organization was established and actually put on a working basis.

The Space Act made explicit provisions for coordinating power in the Space Council as a means of assisting and advising the President in the aeronautics and space field.

These provisions in section 201(e) are as follows:

Designate and fix responsibility for the direction of major aeronautical and space activities;

Provide for effective cooperation among all departments and agencies * * * specify, in any case in which primary

¹⁰⁶ National Aeronautics and Space Act of 1958, 42 U.S.C. 2451.

¹⁰⁷ S. Rept. 100, 1959, p. 7.

¹⁰⁸ Id., p. 8.

responsibility for any category of aeronautical and space activities has been assigned to any department or agency, which of those activities may be carried on concurrently by other departments and agencies; and

Resolve differences arising among departments and agencies * * *.

It is clear that the Council cannot exercise these powers or its other responsibilities for developing a comprehensive national space program without a delegation of authority by the President. This is particularly so with respect to the Council's Chairman and key member, the Vice President. The question of Presidential delegation was recognized when the Space Act was amended in 1961. The language of section 201(e) of the act now provides that it is the function of the Council to advise and assist the President, "as he may request."

This language is not so much a restriction as it is an opportunity for the Council, under the leadership of the Vice President, to exercise vigorous national leadership in the space program at the direction of the President. The Vice President has been given increasingly greater Executive authority and responsibility since the Second World War. As the present Attorney General, Nicholas Katzenbach, said in a memorandum defending the constitutionality of the Vice President's service as Chairman of the Space Council: " * * * the range of duties he may undertake at the instance of the President would seem to be coextensive with the latter's power of delegation."¹⁰⁹

It is difficult to cite all the actual past accomplishments of the Space Council since it must remain a somewhat anonymous part of the Executive Office of the President. Some of the Council's accomplishments, however, are known. In 1961 it was instrumental in establishing the goal of sending a man to the moon in this decade. The Council drafted the President's policy on communications satellites that same year and in the following year drafted the legislative proposals that resulted in the passage of the Communications Satellite Act. In 1963 the Council formulated and recommended to the President the program which led to the initiation of the supersonic transport development. The Council also has been active in stimulating progress in nuclear space power and propulsion systems.

The Council's role in coordination has been uncertain despite its novel central position within the Government to reconcile contending views of the different agencies engaged in space activities. The President has to listen to many voices before policies and decisions can be made about space activities. Even within the Executive Office there is an overlap of advisers, including, besides the Space Council, the Office of Science and Technology and the Budget Bureau. Only the Council, however, has full-time responsibility, continuous interest, and broad expertise with regard to space problems. No one has suggested that access to the President on such matters be limited to the Space Council, but with a delegation of authority from the President, the Council can act as the focal point for decisions and

¹⁰⁹ Hearing before the Committee on Aeronautical and Space Sciences, U.S. Senate, on H.R. 6169, 87th Cong., 1st sess., Apr. 19, 1961, p. 6.

advice in planning the Nation's future space program and in coordinating the space activities of many agencies.

President Johnson has indicated that he will rely on the Space Council and its new Chairman, Vice President Hubert Humphrey, to take a positive role in Government operations in space. Vice President Humphrey also has expressed his desire and willingness to strengthen the reins of the Council.

VIII. RATIONALE FOR A DIVISION OF EFFORT

A recurrent theme of this report is that a neat division of labor between military and civilian space agencies was neither contemplated by law nor workable in practice. Agency planning, research, and project development have responded to practical needs and situations rather than to rigid theories, often leaving the rationale for the division to come after the fact.

JURISDICTIONAL DIFFICULTIES

Efforts to assign exclusive technological areas, projects, or functions in space on an agency basis never have been very successful. For instance, in the early years of the program it was decided that only NASA would build big space boosters. This initial attempt at jurisdictional policy oversimplified the task of space exploration. The military also had to exploit the potential of space in order to enhance its defense mission and to counter possible hostile moves in space. Since the potential of space was unknown, both agencies had to know about the nature of space and how to operate in space. This mutual need resulted in a broad research and development program conducted by both agencies. Space experimentation by the Defense Department necessarily had to focus on definite military objectives and unique operating requirements, but beyond this constraint it was difficult to foretell what systems or hardware would be required. Consequently, the Defense Department initiated the development of the Titan III space booster. This step spelled the end of the attempt to concentrate exclusively in NASA the job of building big space boosters. Although unique military launch requirements were incorporated in the Titan III, at first no particular system use was specified, and the booster was developed as a standardized vehicle for possible use by both agencies.

Another early jurisdictional concept which proved unworkable was in the field of communications satellites. In 1958 NASA and DOD agreed that the civilian space agency would confine its activities to passive satellites while the military would experiment with active repeaters. Progress toward operating communications satellites did not begin in earnest until this early division of effort was discontinued in late 1960. NASA initiated active satellite projects such as Relay and Syncom, and the Defense Department explored the potential of passive systems in its West Ford orbiting "needles" project. Both agencies by this change were involved in passive and active communications satellite development.

Another notion yielding to practical realities is that NASA should have no connection with military activities and vice versa. This idea stems in part from a misinterpretation of the Space Act of 1958. The argument is made that NASA's mission is devoted to peaceful purposes, and that this mission is incompatible with military involvement. As we took pains to point out in section III of this report, the act does not

set up a division of labor between NASA and DOD which exclusively equates NASA with "peaceful" space activities. In the last few years a franker recognition of the broad nature of the Government space effort in research and development, including that of the Defense Department, has broken down NASA's reluctance to associate itself with military activities. For example, NASA has welcomed the direct participation of the military in Gemini experiments. Valuable geodetic and meteorological information come to the Defense Department from NASA's geodesy and weather satellite projects. The Syncom communications satellites built under NASA sponsorship have been turned over to the Department of Defense to serve military needs. NASA is relying on military space efforts to satisfy some of its own needs, such as those in space medicine, satellite stabilization experiments, ground instrumentation, and tracking and launch vehicles. About 20 percent of NASA procurement is handled by the Defense Department. In short, the interests and activities of NASA and DOD have become more closely meshed through a wide range of cooperative agreements or working arrangements. This close inter-relationship of agency activities, though it needs constant adjustment and improvement, is in keeping with the broad mandate of the Space Act which declared "that the general welfare and security of the United States require that adequate provision be made for aeronautical and space activities."¹¹⁰

WELFARE AND SECURITY

General welfare and national security are the two broad areas of concern in space, not a clear-cut jurisdictional division. The technology and knowledge which come from space research and development are of benefit to many civilian and military pursuits, and therefore it is difficult to say dogmatically that particular space projects, such as rocket engine development, manned laboratories, or scientific satellites, are for the "general welfare" and thus the business of NASA, or for "national security" and thus the job of the Defense Department. Both agencies must engage in broad fields of research and development and often in similar fields like boosters and communications satellites. This is not to say that NASA and DOD have the same general jurisdiction and that each can prosecute every kind of project. We analyze this problem more closely at a later point. Here we note that Defense explores space and builds systems in aid of the national security mission. NASA needs no anterior justification for its mission in space, although considerations of national prestige and the potentials for practical applications certainly influence and support its undertakings. The effect of this distinction is that the DOD, more compellingly than NASA, must provide a mission justification, in this case, a military need, for its space pursuits.

The identification of military needs is not a simple task when research and development are at issue. What is a military requirement is subject to many definitions. With respect to space projects, the current Defense Department criteria are extremely demanding. The Secretary of Defense has stated that before a new space project is approved it must promise to enhance military power and mesh with projects of NASA. In addition, each project request is scrutin-

¹¹⁰ Sec. 102(b), National Aeronautics and Space Act of 1958, 42 U.S.C. 2451.

ized closely from a cost-effectiveness basis. However laudable these review standards might be in theory, the effect in practice has been to retard new military space programs, particularly in the manned space flight area.

A skeptical attitude toward military involvement did not stand in the way of early space research and development projects. Although some opinions were voiced in Government after Sputnik that satellites offered no practical promise, the Defense Department launched a very ambitious space program which has paid off handsomely today, with experimental and operating systems which meet definite requirements. Improvements of our defense posture have been achieved by using space satellites and systems for optical and electronic reconnaissance, more precise navigation for missile-carrying Polaris submarines, more coverage and speed in communications to crisis areas in the world, capability for detecting nuclear explosions in space, and better targeting information for missiles.

Threats to our security also have materialized in space although they were but dimly apprehended, not clearly forecast, in 1957. Observers have noted, of course, the continuing ability of the Soviets to keep a step ahead:

Thus they have put into space the first satellite, the first living creature, the first man, the first woman, the first multiman spaceship and now the first man to step out of the capsule and into space itself. They also hold the world records for time in orbit, orbital distance, orbital weight lifted, and highest orbital altitude.¹¹¹

The Soviet Union reportedly possesses some capability to knock satellites out of action.¹¹² There are also indications that the Soviets orbited at least 14 satellites last year capable of scanning American military installations with camera devices.¹¹³ A communications satellite recently launched in Russia may enhance its capability to receive intelligence reports from distant places. The achievements of the Soviet Voskhod (Sunrise) spacecraft point to possible Soviet military space systems of the future and signify advances over the United States in developing a manned orbital laboratory. In referring to the recent demonstration of the Voskhod, when a Soviet astronaut ventured from his capsule into outer space itself, Vice President Humphrey, also Chairman of the Space Council, said: "We would be foolish if we did not understand the military implications of Soviet space science."¹¹⁴

JOINDER OF PURPOSES

The skeptical attitude regarding military manned space activities, now evident at top management levels in the Defense Department is not quite consistent with approval of other military space programs lacking clearly defined military requirements for operating systems. A review of these other research and development activities indicates that the Defense Department has been as much interested as NASA in space sciences and basic technology. These activities are often

¹¹¹ From speech of Gen. B. A. Schriever, Commander, Air Force Systems Command, before National Association of Broadcasters, Washington, D.C., Mar. 24, 1965.

¹¹² New York Times, Apr. 4, 1965, p. 1.

¹¹³ Aviation Week and Space Technology Feb. 22, 1965, p. 22.

¹¹⁴ Congressional Record (daily edition), Mar. 26, 1965, p. A-1440.

rationalized by reference to ambiguous phrases such as "building block" efforts or "supporting" research and development. In fact, the military have deliberately sought new space technologies, materials, and knowledge, hoping that they might ultimately be of value to later operating systems. The list of accomplishments resulting from these efforts is long and impressive, and significantly, they have aided the civil programs as well as the military; multiple and "piggy-back" satellites launched in Vela and other programs; in-air and sea capsule recovery in the Discoverer program; sophisticated change of orbit, maneuvering, and guidance techniques in Agena and other developments; development of many of the space boosters or engines used by both agencies; study of maneuverable reentry and precise landing methods in the Dyna Soar, Asset, and Start programs; restartable and large solid rocket motors; observation and detection sensors; satellite stabilization by gravity gradient methods; development of lightweight, high-strength boron filaments; and electrical ion engine propulsion experiments. In the scientific research field, DOD rocket probes and scientific satellites have made important discoveries about radiation in the ultraviolet region, micrometeorite bands around the earth, ion density during solar eclipses, extraterrestrial radio noise, electron fine structure in the auroral region, and the relation between solar flares and low energy particles in the space plasma.

The Defense Department cannot justify so extensive or costly a program of space research and technology as NASA, which was created specifically to do such work without undue or overly strict concern for future practical requirements. On the other hand, NASA never has begrudged the military its activity in the field of research and technology. With heavy commitments of its own and a large budget to justify, NASA has seen the merits of a practical and realistic division of labor which would permit the military to carry on work NASA cannot readily do. Moreover, it would be an inefficient use of available resources to refuse the military such work, especially if related to preexisting efforts, some of which are pointed toward meeting specific operational needs. For instance, if a military satellite or spacecraft could accommodate research or technological experiments without interfering with more demanding military aspects of the project or vehicle, it would be unwise and uneconomical to exclude such experiments.

This joinder of purposes works both ways. In the Gemini program military experiments have been incorporated in a NASA-developed project. Although the military might have justified a separate Gemini program, they stand to gain substantially by participation in the NASA program. Similarly, although the Defense Department can well justify separate meteorological and geodetic satellite projects, valuable data are derived for Defense use from NASA projects in these areas.

AEC AND THE REQUIREMENTS PROBLEM

The requirements dilemma has not been limited to the military alone. The problem also has been raised with respect to space work of the Atomic Energy Commission. The Commission finds itself in the position of developing nuclear space applications in response to NASA or DOD requirements. When these agencies, which carry a major

portion of the funding burden for such projects, begin to voice doubts about eventual use of AEC developments, the projects suffer from delays and cancellations.

For instance, in the SNAP program which has developed radioisotopes and reactors as power sources for satellites and spacecraft, a demonstration of the usefulness of these devices in space was not conducted until the flight of a Navy navigation satellite, Transit 4, on June 28, 1961, although development permitted such a demonstration in 1959. As Representative Chet Holifield said later:

* * * we could have put it in flight almost 2 years prior. And I want to point out again, at that time there was no firm requirement for such a device.¹¹⁵

Experts have warned that when the time comes to build large manned space systems, such as space stations for military or civilian operational use, the instruments and electronic equipment envisioned for such stations will require large amounts of power, which may not be available in space unless SNAP isotope and reactor developments are pursued energetically today. Nevertheless, cancellation of each of the SNAP reactor space projects has been proposed at one time or another by the executive branch.¹¹⁶

From such experiences, one AEC Commissioner, James T. Ramey, concluded that—

it is clearly time for the Government to free itself from this "requirements merry-go-round" in research and development, and relegate the requirements system to its earlier and more appropriate role in the field of production items.¹¹⁷

As Commissioner Ramey has pointed out, no one should contend that developments be initiated where there is no apparent future use. Obviously, all concepts and ideas for research and development cannot be allowed to run riot. Careful scrutiny and judgment are required to sort out the more promising ideas and to ensure that projects are wisely planned and managed. But instead of rigorously defined firm operating requirements, research and development projects should be oriented to potential missions or a range of possible applications rather than a single specific mission with a specified time scale which is likely to change. A development project should have an objective and not a "requirement," which is better suited to operational systems work.

Research and development is concerned with investigating the unknown and the untried and thus is often its own justification. As Dr. Edward C. Welsh, the Executive Secretary of the Space Council, said in March 1964:

As we evaluate various projects and proposals in the space program we are frequently confronted with the question: "What is its mission?" or "Is there a requirement for it?" If the answer is that there is no known mission at the present time, except to advance the technology, the right decision may be to go ahead anyway. If we had required a clear-cut

¹¹⁵ "Hearings on AEC Authorization Legislation, Fiscal Year 1965," Joint Committee on Atomic Energy, 88th Cong., 2d sess., 1964, p. 257.

¹¹⁶ Authorizing appropriations for the Atomic Energy Commission for fiscal year 1966, report of Joint Committee on Atomic Energy, 89th Cong., 1st sess., H. Rept. No. 349, p. 24.

¹¹⁷ From remarks by James T. Ramey, Commissioner, U.S. Atomic Energy Commission, before the Ninth Institute on Research Administration of the American University, Washington, D.C., Apr. 20, 1964.

prior mission, we would probably have developed no airplanes, or spacecraft, or, in fact, no wheel.¹¹⁸

Even in approved development projects, the tendency to plan toward eventual operating system leads to trouble, particularly where the field is a new and untried one. Dyna-Soar is a case in point; it was finally canceled because it was overambitious and was trying to cover too many bases and few of them adequately. Instead of trying simultaneously to develop a manned maneuverable spacecraft with high lifting body characteristics and capable of landing almost anywhere on the earth with precise, predetermined accuracy, it might have been wiser to tackle each of these capabilities separately. Such has been the course since the cancellation of Dyna-Soar, although how much net time has been lost is open to question.

DEVELOPMENT VERSUS OPERATIONS

A related question is when to stop development and begin operational use. This question has baffled both NASA and DOD. In the case of NASA, in both the communications and weather fields, NASA reached a point during satellite development and experimentation when operational or commercial use was possible. It was difficult to abandon research and development necessary for further system advances or to phase in operational use by other agencies while still conducting development. Compromises have been effected. In communications a commercial entity was created, the Communications Satellite Corp., to provide an operational, revenue-producing satellite system. Nevertheless, NASA has continued communications developments, particularly in its applications technological satellite program (ATS). It does so with some caution, since it does not want to subsidize directly a profitmaking system which could capitalize on such development work.

In meteorological or weather satellites, the Weather Bureau now is preparing an operational system, using the first satellite development project, Tiros. NASA, however, continues to develop a more advanced system called Nimbus. At an earlier stage, the transition was delayed while the agencies deliberated the advantages and disadvantages of using as the operational system the more advanced Nimbus satellite. Technical questions were involved but so were costs. The Weather Bureau was not anxious to burden itself with the problems and costs of the Nimbus program.

NASA will continue to be faced with such situations as the potentials of space are further realized and exploited. Necessarily it will be brought into closer collaboration with other Government agencies, and it must expect that other Government and nongovernmental entities will assume larger responsibilities in space, even where development is involved in connection with identifiable missions and systems.

A division of labor which would delegate to NASA the entire area of technological and scientific endeavors in space does violence to a practical scheme for national space development. It is out of keeping with the experience of the space program to date, which, as this report

¹¹⁸ From remarks of Dr. Edward C. Welsh, Executive Secretary, National Aeronautics and Space Council, at Goddard memorial dinner, Washington, D.C., Mar. 20, 1964.

has attempted to recount, has never been able to conform to artificial or arbitrary concepts formulated from time to time by those who want a clean line of division in space technology. There is as much danger in rigid compartmentalization as in obliterating all lines between agencies and missions. The concept of a national space program, so much in favor today, might lose its effectiveness as a working principle if consideration is not given to the real capabilities and the unique needs of different agencies. Neither will the country have a true national space program if distinctions between military and civil roles are blurred. A national space program is not an amorphous, vague proposition in which every effort is designed to meet all the specific objectives of different missions and agencies. It is true that, where broad research and development are involved, space technology has many potential applications. In this sense the work of NASA helps the military and vice versa, but not always. Where demanding priorities, unique needs, and specialized resources are concerned, only the agency associated with them can direct the particular project.

A truly viable and coherent national space program should divide the labor in accordance with practical realities and experiences. The history recounted in this report indicates the effectiveness of this principle. The Space Act of 1958 gave sufficient scope to such considerations. The Congress left the division of space labors to the judgment of the executive branch—the President, the Space Council, and the individual agencies. Both the Space Act and practical considerations dictate that NASA will continue to play the widest and largest role in space activities, particularly in research and development. The military must recognize this preeminent role of NASA, cooperate with the agency, and learn from its accomplishments without fearing that it will diminish the military responsibility for national security. By the same token, the military must be allowed to investigate and exploit fully the space potentials in keeping with the proper execution of that responsibility.

Beyond these broad considerations, the following factors seem to be relevant to decisions governing allocation of future space activities among Government agencies: (1) definable agency and mission needs; (2) unique agency requirements; (3) relative priorities; (4) previous related experience; (5) availability of resources in facilities, personnel, and program offices; (6) potential effect on other projects; (7) scheduling demands; (8) distinctive management expertise; (9) the possibilities for preventing duplication or promoting cooperation; (10) suitability for joint project management; (11) relative costs and times to completion as between one agency managing a project and another; and (12) the relationships to the budgetary framework of the agency, the entire space program, and the total Federal budget.

THE OUTWARD AND INWARD LOOK

There remains to be considered the suggestions made in Government circles and elsewhere that the proper rationale for delineating NASA and DOD space missions would have the military emphasize near-earth space activities and NASA those in outer space. This rationale deserves analysis. It offers no definitive solutions to key questions of public policy in space, but it suggests some useful guidelines or points of orientation. A useful way to examine the problem

is to consider the new and developing capabilities for space flight from two vantage points: looking outward from the earth and looking inward from space toward the earth.

Looking outward, space flight offers the opportunity to send instruments and eventually men to other celestial bodies; to acquire information about them; and to add to our store of knowledge in ways not otherwise attainable. Space flight also enables men to observe the universe from outside the atmosphere, avoiding its filtering effects which bar much information from reaching the earth's surface, and eliminating the atmospheric distortions which interfere with observations from the ground.

From this vantage point—looking outward—the quest for scientific knowledge calls for exploration and research on the nature of the universe, and particularly on the constitution and characteristics of other celestial bodies. Great new scientific adventures beckon the investigator, and unlimited achievements are in prospect to serve the scientific quest and enhance the Nation's prestige. The problems of looking outward from the earth, of deep space exploration, are logical assignments to NASA. These include the investigation of other planets, the analysis of the sun and stars, and the manned trip to the moon. Consequently, one would expect this agency to lead the development of the instruments, spacecraft, and techniques essential to these missions. Where appropriate, of course, it should use the support of the military just as the military should use the support of the NASA research and technology. The responsibility, however, for planning, organizing, and carrying out the duties of deep space exploration properly rests with NASA.

Looking inward toward the earth, certain functions fall clearly within the military domain; others have both military and civilian aspects and involvements. Before examining these more closely, it may be useful to consider the important capabilities which space vehicles looking inward toward the earth can give in ways not previously attainable. These are four:

- (1) Line of sight to very large areas of the earth's surface.
- (2) Extremely high speeds (approximately 10 times faster than aircraft).
- (3) Infinite flight duration.
- (4) Highly predictable flight paths or orbits (including the unique 24-hour or stationary satellite orbit).

The "line of sight" feature, resulting from the extreme altitudes attainable in space flight, has evident uses in fact and prospect, the principal ones being communications relay, weather observation, reconnaissance, early warning for ICBM attack, and (when combined with the characteristic predictability of satellite orbits) navigation assistance. Schemes have been postulated whereby satellites in orbit could detect the launch of ICBM's and destroy them, by sending either weapons or energy beams against the attacking missiles. The problem of survivability of command and control posts has led to the suggestion that a command and control station be maintained in an orbit to survive better and provide retaliation in the event of nuclear attack. All of these applications derive from the usefulness of the "line of sight" to large areas of the earth, combined in many cases with the infinite duration of satellite orbits and in some cases, such

as the navigation satellite, with the highly predictable nature of the orbit.

The other novel characteristic of space flight is the very high speeds, better than 5 miles per second, attainable outside the atmosphere. This characteristic of space flight was first exploited with the invention of the ICBM. While ballistic missiles are not usually thought of as space vehicles, actually an ICBM spends about 25 of its 30 minutes of flight time in space above the atmosphere, and it differs from a satellite only in that its speed is usually slightly lower, and its elliptical Keplerian orbit is selected to intersect the earth at the target point instead of missing the top of the atmosphere.

That satellites as well as ballistic missiles could be used for bombardment is a suggestion often heard and as often discounted. Bombardment from satellites basically is feasible, but most analyses show such a military weapon system to be inferior to conventional ICBM's. It is not clear that this inferiority will remain for all time, or in fact, necessarily exists under all circumstances even today. Presently the higher cost of launching a satellite compared with that of a ballistic missile, the problems of keeping the satellite working in space until the user wishes to employ it, and the concern over counter-measures and malfunctions, combine to rate the bombardment satellite far less effective than the ballistic missile.

From the foregoing discussion, it is clear that certain space missions have only, or mainly, a military aspect and are, therefore, properly the primary responsibility of the Department of Defense. These include reconnaissance, early warning, bombardment from satellites, inspection of other satellites, command and control, and anti-ICBM satellites. Little question can be raised about the military responsibility for these areas.

MUTUAL INTEREST AREAS

If we examine the space systems or functions which have common military and civilian space aspects, we find them to be communications, weather, navigation, geodesy, Van Allen belt monitoring, and booster development. It is not difficult to demonstrate that the military requirements in these mutual-interest areas for the most part are more severe than the civilian. If we follow the criterion that agency functions or responsibilities should be assigned on the basis of severest requirements, a good case could be made for assignment of most mutual-interest areas to the Department of Defense. However, by law, policy and practice, exclusive military involvement is not sanctioned.

Thus, in the area of satellite communications, the military have a strong and urgent requirement, even while civilian and commercial agencies also are committed. The military have need to communicate to any place on the earth without delay and in spite of enemy attempts to jam communications links. This requirement for jam-free worldwide communication generally imposes more severe specifications on the development of a communications satellite system than do the civilian requirements for intercontinental television or for expanded telephone service. The Department of Defense must have its own satellite communications system to meet special military needs, as the committee has shown in another report.¹¹⁹ At the same time,

¹¹⁹ H. Rept. No. 178, 89th Cong., 1st sess.

commercial applications are being developed by the Communications Satellite Corp., and additional research and experimentation are being conducted by NASA.

Again in the case of weather satellites, the military must have worldwide information on weather. The Navy needs to know sea weather in all areas of the world, while the Air Force and Army have need for detailed weather data over foreign land masses. Worldwide weather information also is helpful for civilian forecasting in the United States, and no less than 17 Government agencies are engaged in operations and research which bear upon weather prediction and control, with the Weather Bureau as a long-established focal agency on the civilian side. The Tiros and Nimbus weather satellites, which account for a sizable portion of the funds for weather research and development, are NASA programs. Nevertheless, as we have shown in a separate committee report,¹²⁰ the Department of Defense now expends more than half of the yearly Federal outlays for meteorological operations and services, and about one-third of the Federal outlays for research in the atmospheric sciences.

Navigation and geodetic satellites have both military and civil applications. At the present time, the military requirement for precise navigational information for missile-carrying Polaris submarines is being met by the Navy's operational navigation satellite system. Commercial and other civil maritime and aviation users have an interest in the development of navigation satellites. A joint inter-agency committee is studying these civil aspects, and NASA will conduct navigation experiments in its Applications Technology Satellite program. Both NASA and DOD are actively engaged in geodetic satellite projects, although NASA at present is primarily responsible for this field.

Monitoring of the Van Allen belt and learning more about the basic nature of the radiation is a research function which falls within the NASA charter. It appears that the prime missions of NASA involve either going through the belt quickly or operating below it, whereas the military are concerned mainly with near-earth space orbits and have a need for continuous information on near-earth space radiation. In particular, since the high-altitude nuclear bomb tests have shown that space is subject to loading with electrons which may be damaging to military satellites, it is essential for the military to have continuous information on radiation status. The urgency of the military requirements dictates a continuing military role in the monitoring of space radiation.

Two areas of space systems and hardware remain to be considered. One of these is space boosters; the other is the manned orbital space station discussed briefly above. In the booster field, development should be aimed toward meeting requirements for frequent and inexpensive launching of payloads. Certainly the military will have such requirements, for they are interested in systems which will operate 24 hours a day, 365 days a year. They will need the capability to bring back payloads from space, to repair and relaunch them, or to service large spacecraft. The civil requirements point in the same direction, for NASA has projected a broad range of developments

¹²⁰ H. Rept. No. 177, 89th Cong., 1st sess.

in space technology for scientific purposes and potential civilian or commercial applications.

Cheaper launching costs must be accompanied by a change in philosophy of operation—a change away from today's pattern when each space venture is treated as a large, crucial, heavily instrumented and continually monitored experiment—to a procedure more like that used in airline operations. We would not think of throwing the airplane away after one flight. The military need to be particularly concerned because, to keep the Defense budget within bounds and accommodate expanding space operations, it is essential to develop means of launching objects in space which are from one to two orders of magnitude cheaper than today's throwaway boosters.

NASA's requirements for exploration of other planets involve very large boosters, which, from a technical standpoint, would be much more difficult to make reusable. An example is the Saturn V. Hence, throwaway booster systems will continue to be used in this area for a long time. For research, for exploration, for prestige, the big throwaway booster is an essential piece of equipment. NASA's responsibility for very large booster developments is clear; that of the military less so, for their missions in the foreseeable future can be accomplished with payloads varying from a few hundred to a few tens of thousands of pounds. The military profitably can give greater attention to the development of low-cost reusable boosters, which, in terms of cost and technology, are within reach of attainment.

Finally, the orbiting space station may be viewed from the vantage point of the inward and outward look. NASA needs an orbiting laboratory to look outward, to establish a space observatory by which it can view the planets and stars. Also, NASA will be interested in experiments for manned observation in quest of domestic and commercial applications, as well as of scientific knowledge. But more urgently, at this time, the military need such a station to look inward—to serve as a laboratory for new or improved military space systems. Unquestionably, both NASA and the Department of Defense need low-orbit space stations in exercise of their respective missions. For reasons outlined above, we believe that the national security calls for primary emphasis to be given at this time to the full-scale development of a military space laboratory.

MAJOR CONSTRAINTS ON SPACE ACTIVITIES

The requirements and potentials in space make it worthwhile to consider here, even if briefly, the major constraints on space exploration and development as we know them today. These may be summarized as follows:

- (1) The extreme cost (in excess of \$1,000 per pound) of launching payloads into space.
- (2) The lack of reliability or the inability to build satellites that will operate for a long time unattended without failure.
- (3) The absence of a simple reliable way of returning from space to a controlled landing at a specified point.
- (4) The intense radiation of the Van Allen belts and of solar flares.

As in any other area of technology, major progress can be expected toward the solution of these problems. In the matter of launching

costs, for example, while today it costs over a thousand dollars per pound to place satellites in low orbits, the propellant used in the flight costs but a dollar or two a pound. The high launching cost essentially is due to the fact that the space booster or flying machine which places the satellite in orbit is thrown away with each launch. Studies underway now indicate that it may be feasible to build space boosters which can be recovered and used over again. Potentially in the distant future, therefore, access to space could become much cheaper, perhaps as cheap as \$50 per pound in low orbit. In the meantime, space only can be used with throwaway booster systems. Applications are limited to those where the results are worth the enormous cost of \$1,000 to \$2,000 per pound for placing payloads in low orbit, up to numbers of \$10,000 per pound for high orbits and still higher for lunar round trips.

The high cost of placing payloads in space might not be such a serious problem for functions such as communications relay and weather observation if the satellites would work indefinitely once placed in orbit. However, the state of the art of equipment construction and the problems of making electronics work in the radiation of the Van Allen belts tend to limit the useful life of satellites to much shorter periods than are consistent with good economics. With extensive effort the lifetime or mean-time-to-failure can be reduced, but the satellites become increasingly expensive, frequently costing as much as \$10,000 per pound.

Again, in the future this problem probably can be eased if we develop low-cost space launchings, and if we find better methods of space recovery such as were contemplated in the X-20 (Dyna Soar) vehicle. New approaches to exploiting space would become feasible. Satellites, for example, could be launched and provided with a recovery system so that if trouble developed they could be brought back, repaired and relaunched. Alternatively, if they were very large and complicated, and the costs of launching were sufficiently lowered, men could be sent up in a rendezvous vehicle to repair them. In the ultimate, the satellite could be manned continuously with crews being rotated by ferry vehicles.

Thus, the development of low-cost launching systems together with good recovery systems would greatly facilitate the exploitation of space. Alternatively, new techniques in electronics and equipment may be applied to develop equipment of sufficient reliability and low enough weight that even at the launching cost of \$1,000 per pound and the satellite cost of \$10,000 per pound, the useful life may be sufficient to make the application economically sound. It is important to note, however, that there are ways of making the access to space cheap and of making the application of space systems to their potential purposes fall within reasonable economic limits. To date the effort devoted to making space more accessible, or more useful once entered, has been relatively small compared to that devoted simply to utilizing it by the brute-force approach. If the United States is to lead in space operations, it is important that additional attention be given to reducing the launching costs and extending the lifetime of satellites.

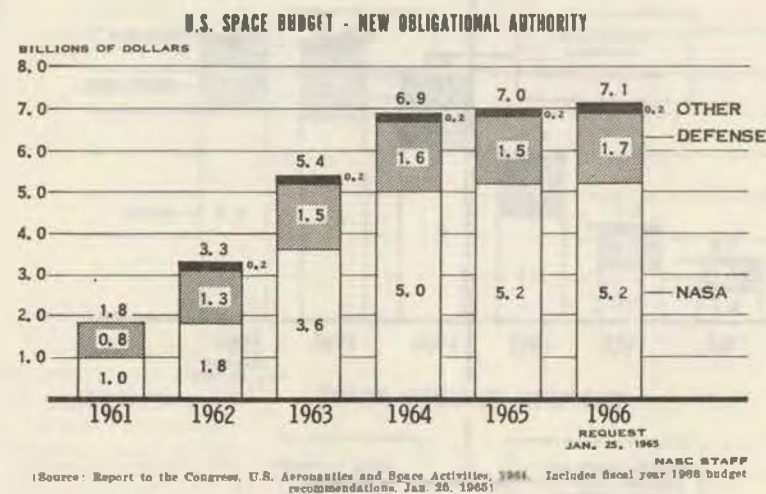
APPENDIXES

APPENDIX A.—U.S. SPACE BUDGET, FISCAL YEARS 1955-1966.

	NEW OBLIGATIONAL AUTHORITY (In millions of dollars)						Total Space
	NASA		Dept. of Defense	AEC	Weather Bureau	NSF	
	Total	Space 1/					
<u>Historical</u>							
1955	56.9	56.9	3.0	-	-	-	59.9
1956	72.7	72.7	30.3	7.0	-	7.3	117.3
1957	78.2	78.2	71.0	21.3	-	8.4	178.9
1958	117.3	117.3	205.6	21.3	-	3.3	347.9
1959	338.9	268.9	489.5	34.3	-	-	792.7
1960	523.6	461.5	560.9	43.3	-	.1	1065.8
1961	966.7	928.7	813.9	67.7	-	.6	1810.9
1962	1824.9	1796.8	1298.2	147.8	50.7	1.3	3294.8
1963	3673.0	3626.0	1548.1	213.9	43.2	1.5	5432.7
1964	5100.0	5046.6	1604.1	210.0	2.8	3.0	6866.5
<u>1966 Budget</u>							
1965	5250.0	5179.8	1546.7	236.0	15.4	3.1	6984.0
1966	5260.0	5181.6	1670.2	225.2	33.1	3.8	7113.9

1/ Excludes amounts for aircraft technology in 1959 and succeeding years. Amounts for NASA-NACA aircraft and space activities not separately identifiable prior to 1959.

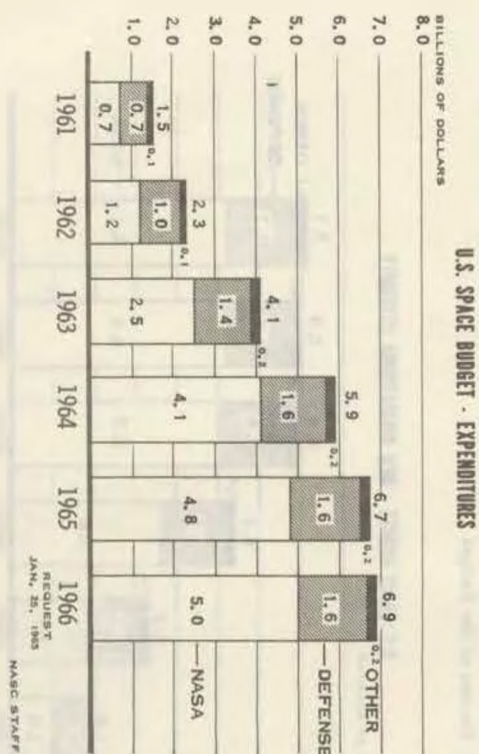
Source: Bureau of the Budget



Historical	EXPENDITURES (in millions of dollars)						Total Space
	Total NASA	Space 1/	Dept. of Defense	AEC	Weather Bureau	NSF	
1955	73.8	73.8	1.5	-	-	-	75.3
1956	71.1	71.1	16.5	6.3	-	-	100.1
1957	76.1	76.1	47.5	19.2	-	-	150.1
1958	89.2	89.2	135.5	20.2	-	-	248.9
1959	145.6	58.8	341.0	32.6	-	1.5	433.9
1960	401.0	329.2	518.1	41.1	-	-	888.4
1961	744.3	693.6	710.0	64.3	-	-	1,467.9
1962	1,257.0	1,225.9	1,028.8	130.0	1.0	.9	2,386.6
1963	2,552.3	2,516.8	1,367.5	181.0	12.2	1.1	4,078.6
1964	4,171.0	4,131.3	1,563.5	220.1	12.3	2.6	5,929.8

1966 Budget
1965 4,900.0 4,837.3 1,570.0 231.2 15.0 3.0 6,656.5
1966 5,100.0 5,031.5 1,610.0 227.9 16.6 3.6 6,889.6

1/ Excludes amounts for aircraft technology in 1959 and succeeding years. Amounts for NASA-NACA aircraft and space activities not separately identifiable prior to 1959.
Source: Bureau of the Budget.



APPENDIX D.—Agreements Between the Department of Defense and the National Aeronautics and Space Administration

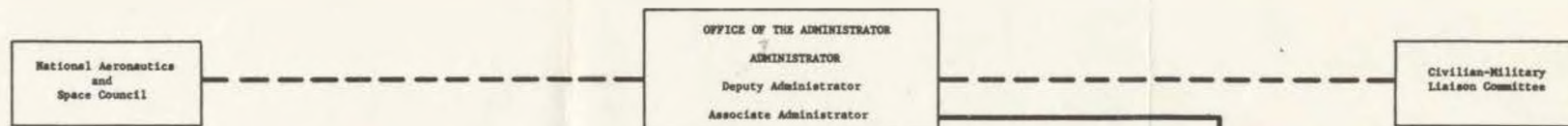
Introductory note: The agreements listed below are the major agreements relating to space activities between the agencies. Each agreement listed is a written document, the full text of which is in the files of the committee. Agreements marked with an asterisk (*) were signed by the Administrator of NASA and the Secretary of Defense, or their Deputies. The committee has attempted to compile a complete list of agreements executed at the headquarters level or by Washington, D.C.-based divisions. In addition, there is an undetermined number of working or field level agreements, some of which implement the agreements listed below.

No.	Date	Parties	Subject	Description
1	Oct. 1, 1958	DOD-NASA	Vanguard	Transfers records, property, facilities, and civilian personnel to NASA.
2	Oct. 14, 1958	Air Force-NASA	Solid Rocket Test Vehicle	Cooperative arrangement to develop separate solid rocket development programs for Air Force and NASA requirements. Scout program.
3	Nov. 20, 1958	ARPA-NASA	Manned Orbital Vehicle	Establishes NASA responsibility for direction of Project Mercury with support of DOD; \$8,000,000 of fiscal year 1959 ARPA funds transferred to NASA; joint working committee to advise NASA Administrator.
4	Nov. 23, 1958	DOD-NASA	Idle Production Equipment	Prescribes general policies and procedures by which NASA can secure idle production equipment of the DOD for relieving production bottlenecks on NASA programs.
5	Dec. 3, 1958	Army-NASA	Jet Propulsion Laboratory	Transfers general management and technical direction of JPL to NASA except for military projects; Army to continue contractual relations in 1959, mainly for Sergeant missile program.
6	do	do	NASA Use of Army Ballistic Missile Agency (ABMA).	ABMA, Huntsville, to remain under Army control; Army to accomplish NASA work under specific project requests consistent with Army program schedules.
7	Dec. 14, 1958	Air Force-NASA	Dyns Soar	Air Force to have management and technical control of hypersonic boost glide system development with advice and assistance of NASA; flight test by NASA, Air Force, and contractor under joint NASA-USAF committee chaired by Air Force.
8	Dec. 19, 1958	Navy-NASA	Upper Air Research Program	Transfers certain employees of the Naval Research Laboratory and upper air research program to NASA.

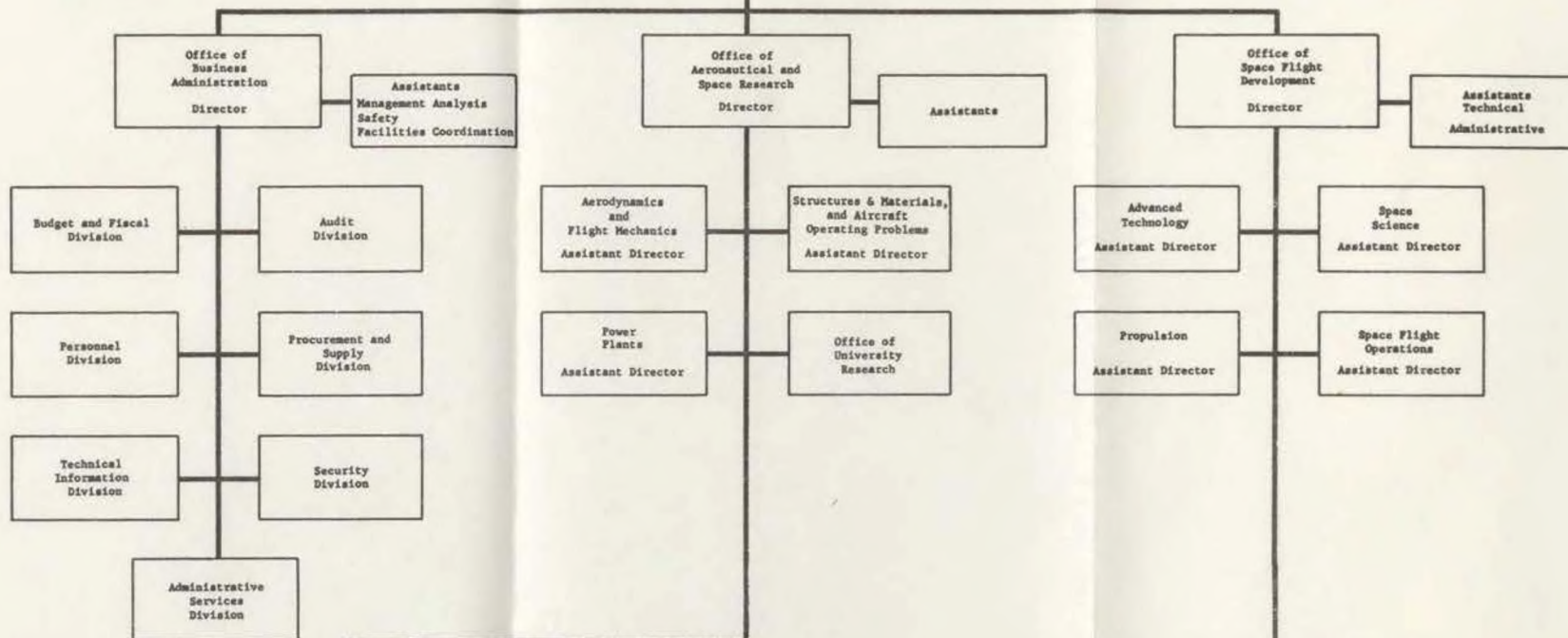
APPENDIX B.—NATIONAL AERONAUTICS AND SPACE ADMINISTRATION ORGANIZATION CHARTS.

Organization Chart—1959

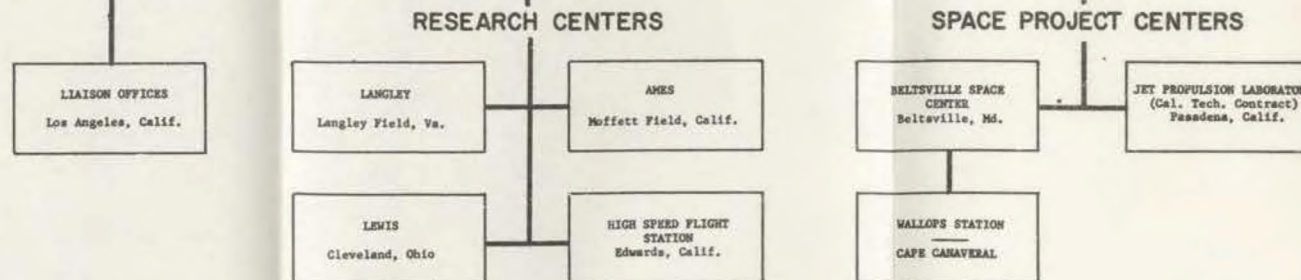
EXECUTIVE DIRECTION



PROGRAMING OPERATIONS

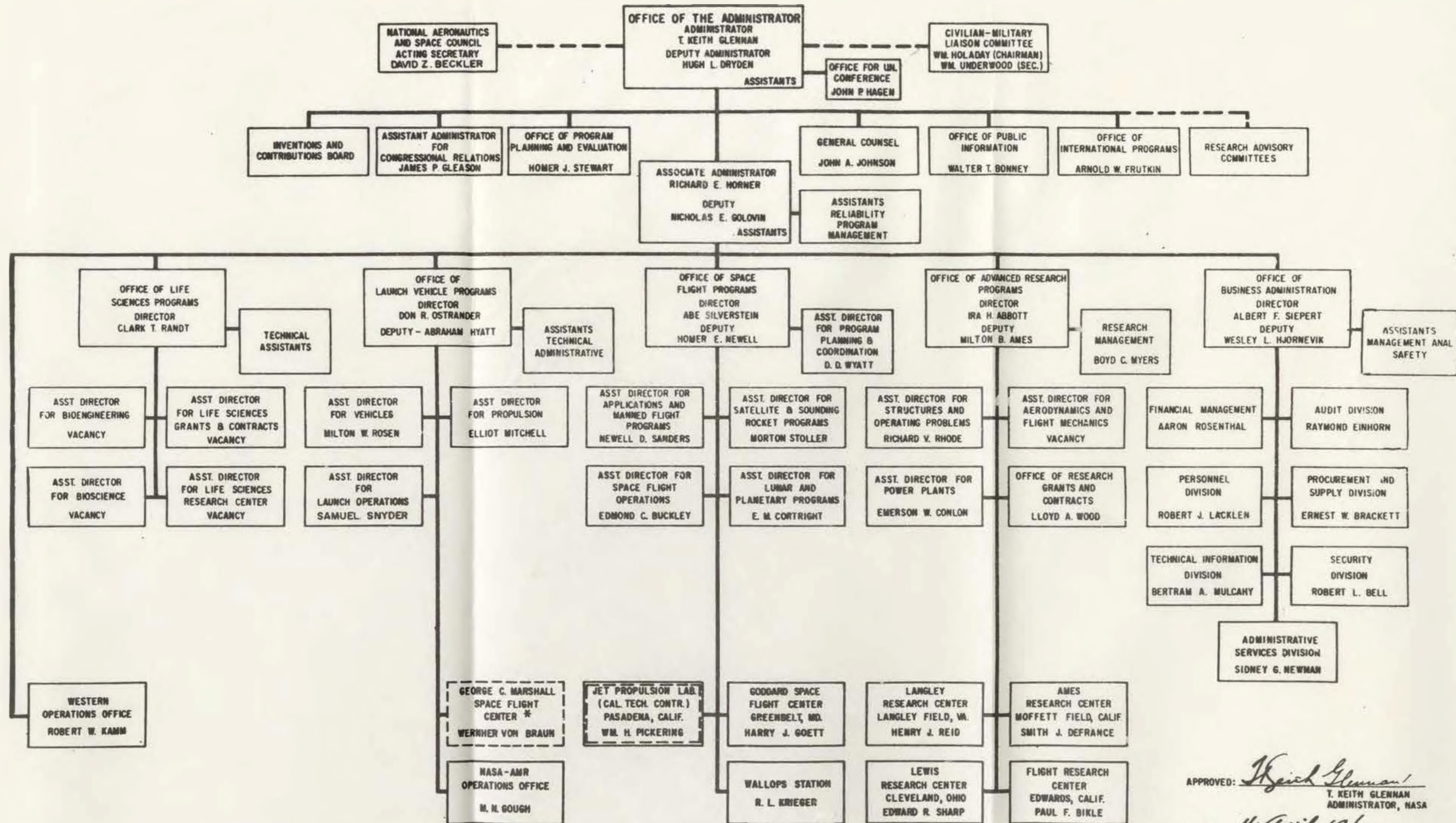


FIELD ACTIVITIES



Approved: *Keith Glennan*
T. Keith Glennan
Administrator, NASA
Date: *29 Jan 1959*

Organization Chart—1960



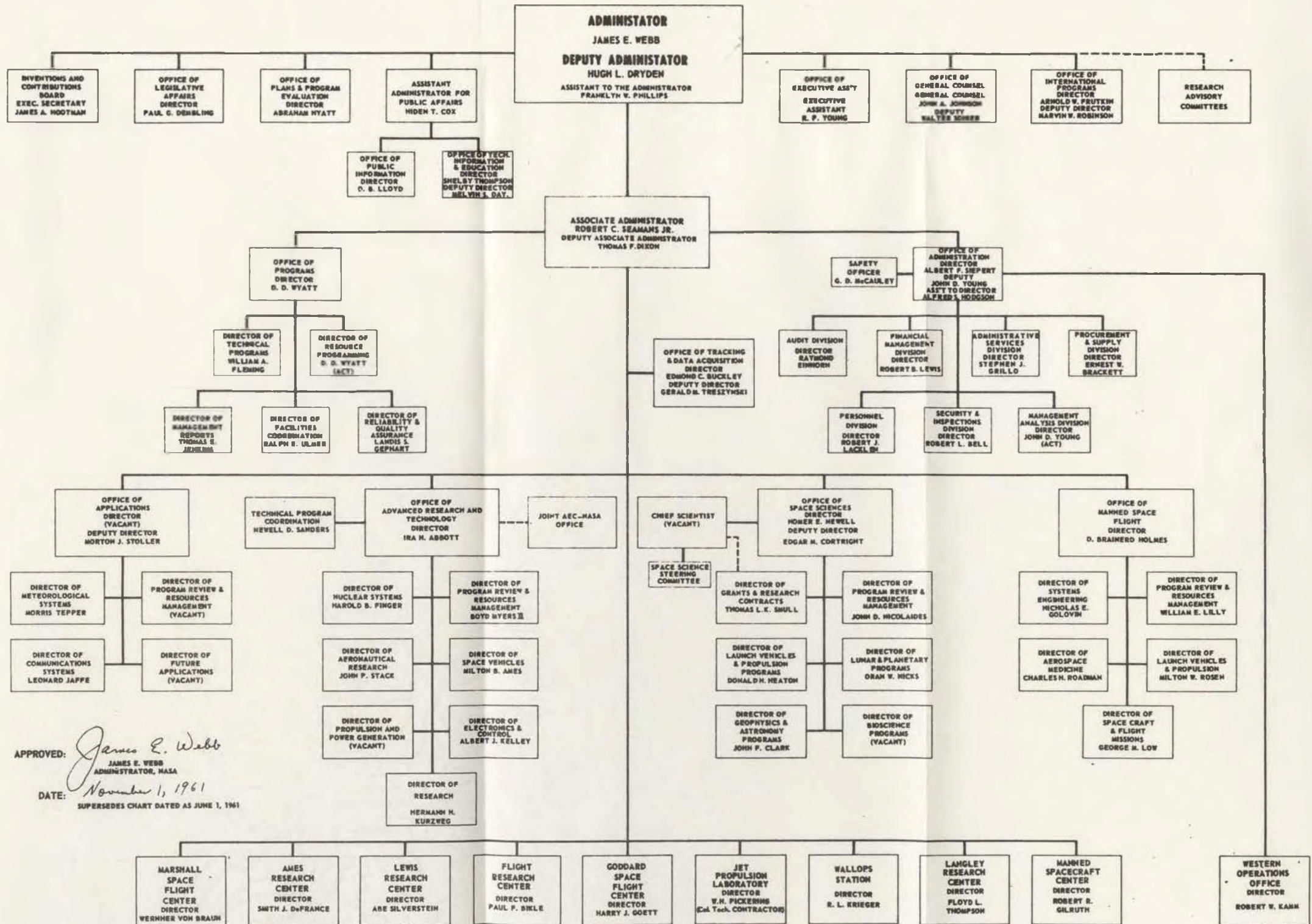
* TRANSFER FROM U.S. ARMY
PENDING TO BE EFFECTIVE
JULY 1, 1960.

APPROVED: *T. Keith Glennan*
T. KEITH GLENNAN
ADMINISTRATOR, NASA

DATE: *4 April 1960*

SUPERSEDES CHART DATED FEBRUARY 7, 1960

Organization Chart—1961

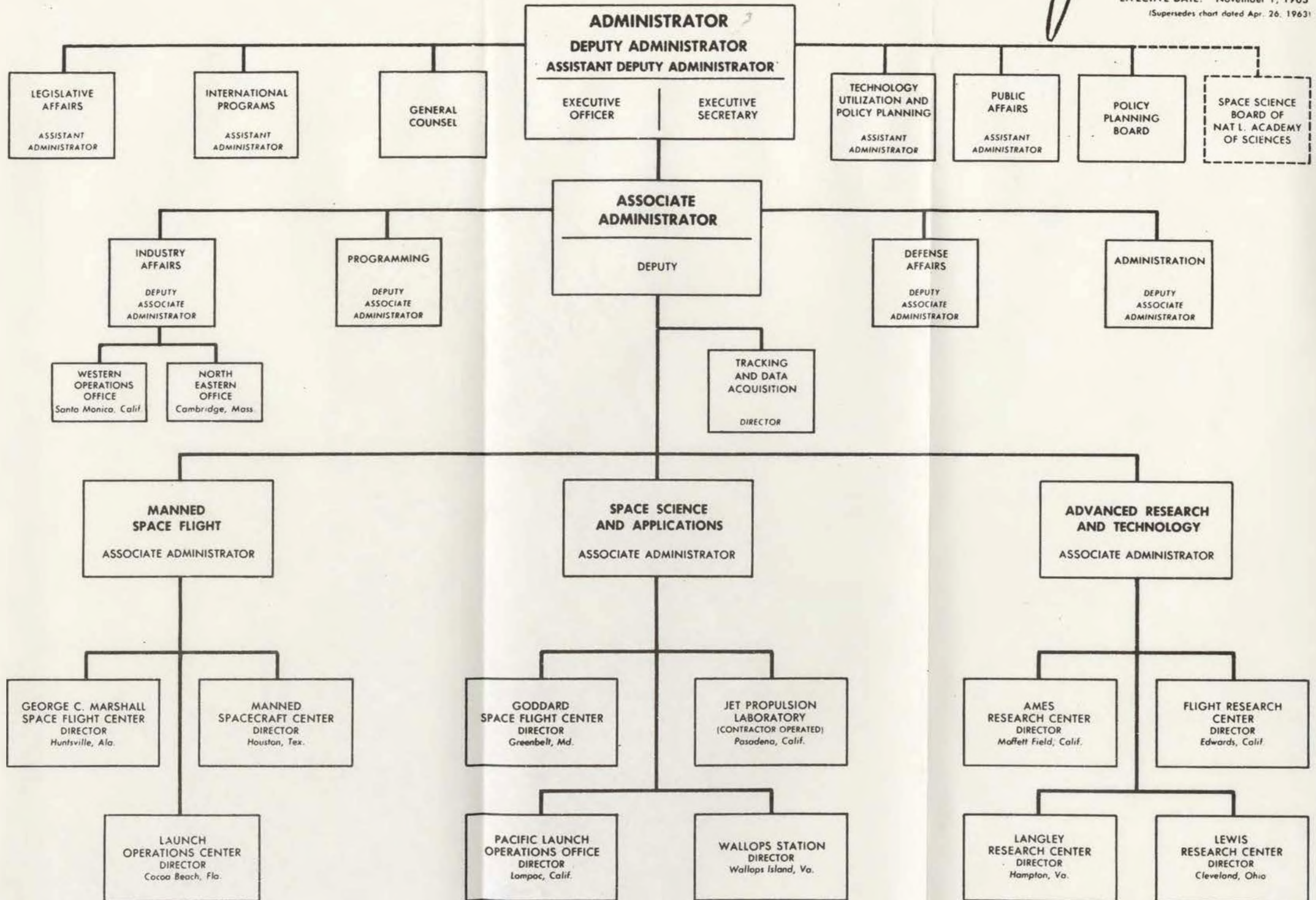


APPROVED: *James E. Webb*
JAMES E. WEBB
ADMINISTRATOR, NASA
DATE: *November 1, 1961*
SUPERSEDES CHART DATED AS JUNE 1, 1961

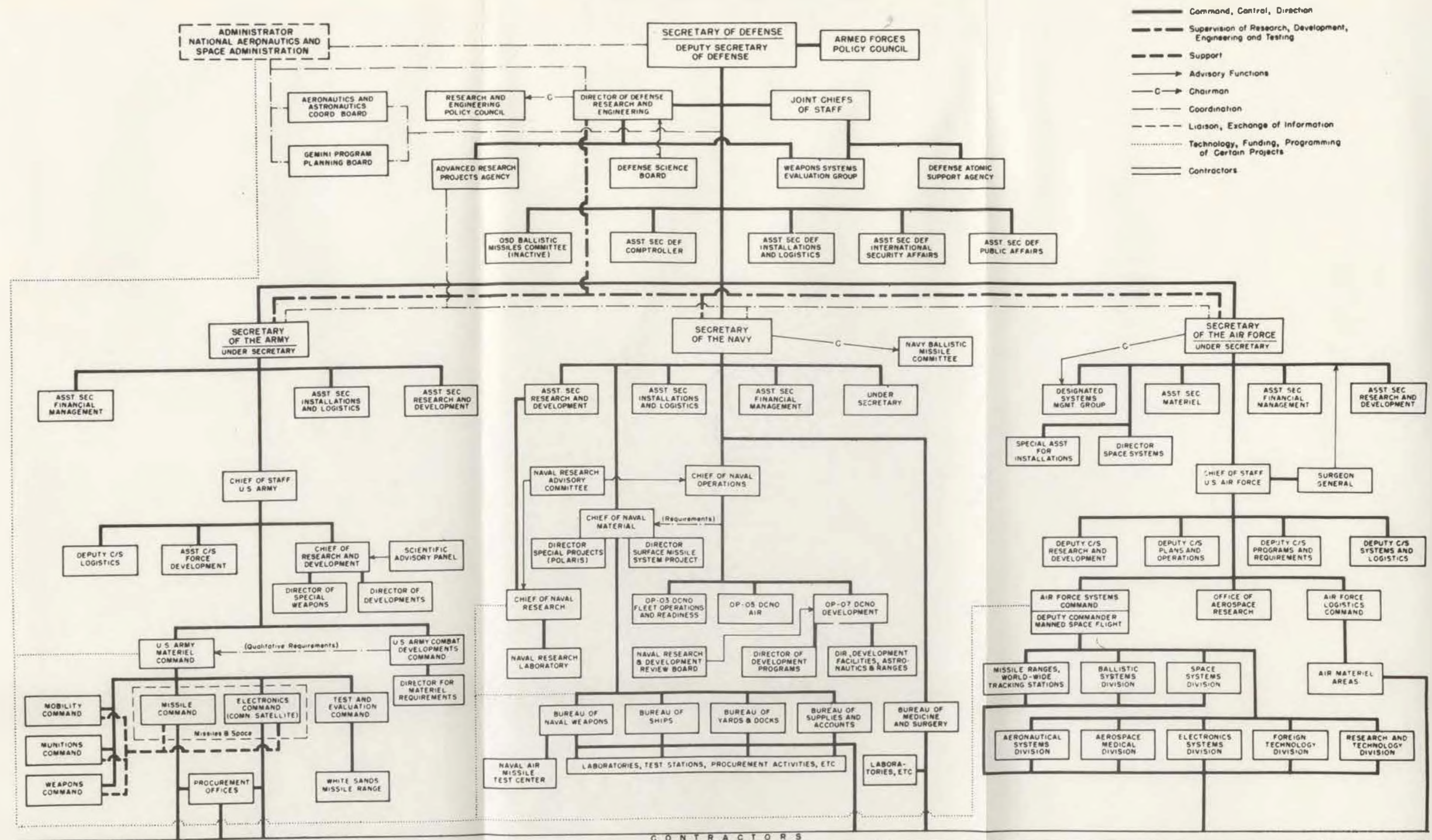
Organization Chart—1963

APPROVED

James E. Webb
ADMINISTRATOR
EFFECTIVE DATE: November 1, 1963
(Supersedes chart dated Apr. 26, 1963)



U. S. MILITARY SPACE AND MISSILE PROGRAMS FUNCTIONAL ORGANIZATION



No.	Date	Parties	Subject	Description
9	Jan. 10, 1959	DOD-NASA*	Tracking and Data Acquisition	Provides for cooperation on tracking and data acquisition; provision by NASA of deep space tracking stations in Australia and Africa for NASA and DOD programs; DOD to provide similar stations in Spain and Japan for NASA and DOD programs; NASA to provide for Mercury and Minitrack networks; agencies to exchange data and provide mutual support; NASA-DOD technical committee to maintain continuing study and monitoring of global tracking and data arrangements.
10	Feb. 4, 1959	Navy-NASA	Research Support	Navy to furnish aircraft to NASA without reimbursement; NASA to conduct research at Navy facilities without reimbursement.
11	Apr. 3, 1959	DOD-NASA*	Detailing of Military Personnel to NASA	Procedures for tours of duty for military personnel with NASA, including ROTC graduates; NASA to submit requests through Civilian-Military Liaison Committee.
12	Apr. 13, 1959	NASA-DOD	TIROS	NASA to assume direction of meteorological satellite project, TIROS advisory committee of DOD and NASA established to provide for DOD requirements and for exchange of information; ARPA to fund \$11,600,000
13	May 20, 1959	Air Force-NASA	Air Force Aircraft	Air Force to furnish aircraft to NASA without reimbursement.
14	Aug. 13, 1959	Army-NASA	Jet Propulsion Laboratory	New capital equipment acquired by JPL, assumed to be for non-Army purposes unless otherwise identified; orders from NASA to Army subject to reimbursement.
15	Sept. 30, 1959	NASA-Air Force	ROTC Graduates	NASA to request ROTC graduates of Air Force with degrees in physical science or engineering for 2-year duty tours; may continue after tour as career officer assignee; total assignees not to exceed 75.
16	Oct. 21, 1959	NASA-DOD*	Large Boosters	Assigns to NASA sole responsibility for development of very high thrust space boosters; transfers to NASA the Development Operations Division of Army Ballistic Missile Agency, Huntsville, including Saturn project. (Approved by President, Nov. 2, 1959.)
17	Nov. 12, 1959	NASA-DOD*	Reimbursement Principles	Provides, in case of agency placing an order with the other for contracting out, that reimbursement will be limited to direct costs; in-house orders to be performed under standard procedures used for all customers of Government; when agency assigns contracts for purposes of administration, administrative costs may be reimbursed; materials to be reimbursed with the exception that equipment on loan may be without charge; construction by DOD for NASA to be charged directly to NASA funds; when either agency is tenant on installation of the other, all direct costs reimbursed.

18	Jan. 12, 1960	DOD-NASA	Project Mercury	NASA to exercise overall control of flight test operations with representative in blockhouse at Cape Canaveral; Army to be responsible for checkout and launch of Redstone; NASA responsible for capsule system.
19	Feb. 23, 1960	NASA-Air Force	Launch Stand Loading Schedules at Atlantic Missile Range	Arrangements to prevent conflicts between space and missile launch schedules; NASA-Air Research and Development Command committee established to prepare schedules.
20	Mar. 30, 1960	Navy-NASA	Cost Reimbursement	Establishes principles for reimbursement of costs of Project Mercury recovery operations; fleet commander to compute costs of ship and aircraft operations on prorated hourly and daily basis.
21	Apr. 4, 1960	NASA-Army Corps of Engineers	Construction Procedures	Establishes procedures for Corps of Engineers design and construction of NASA facilities; NASA to make requests for design or construction services directly to Corps; NASA responsible for obtaining real property.
22	July 15, 1960	DOD-NASA	Industrial Security Program	Provides for NASA use of DOD industrial security program.
23	Aug. 1, 1960	Army-NASA	Army Assistance in Administration of NASA Contracts	Army to provide procurement administration functions as requested in NASA-placed contracts including precontract and contract administration services, subject to reimbursement under principles of Nov. 12, 1959, DOD-NASA agreement; NASA to retain technical direction of its contracts and assign technical representatives to plants or laboratories; use of Army facilities subject to prior written Army consent.
24	Aug. 15, 1960	NASA-Army	Facilities at Redstone Arsenal	Implements transfer of portion of Army Ballistic Missile Agency to NASA; Army grants irrevocable use for 99 years of portion of Redstone Arsenal, Huntsville, Ala., to NASA; NASA to have full control over its portion with exception of Army right of access to utilities and certain support facilities; NASA to be represented on Arsenal Master Planning Board. (Revised Apr. 19, 1961 and Oct. 9, 1962 to include additional NASA land.)
25	Aug. 25, 1960	NASA-DOD	Coordinating elements	Dissolves various NASA-DOD coordinating and advisory panels.
26	Aug. 27, 1960	Air Force-NASA*	Communications Satellites	Revises understanding of November 1958 in which ARPA delegated active satellite responsibility and NASA passive satellites; in this agreement of 1960, DOD passive West-Ford Project confirmed; NASA to move into active field; recommends exchange of program information and later detailed division of responsibilities in active satellite field.
27	Sept. 13, 1960	NASA-DOD*	Aeronautics and Astronautics Coordinating Board	Establishes AACB for coordination of policy and management of space program; Board responsible for facilitating (a) planning to avoid undesirable duplication and to achieve efficient use of resources; (b) coordination; (c) identification of problems; and (d) exchange of information. Board to be headed by Deputy Administrator of NASA and Director of Defense Research and Engineering as cochairmen; panels established in areas of manned space flight, unmanned spacecraft, launch vehicles, space flight ground environment, supporting research and technology, and aeronautics, with equal civil-military representation; actions based on Board consideration of matters "may be taken by individual members."

No.	Date	Parties	Subject	Description
28	Sept. 15, 1960	Air Force-NASA.....	Air Force Procurement Assistance to NASA.	NASA agrees to conform as closely as possible to Air Force practices and procedures in carrying out its own procurement program; certain NASA contracts to be administered by Air Force using provisions of Armed Services Procurement Regulations; NASA to use Air Force field service functions.
29	Dec. 1, 1960	NASA-Air Force.....	NASA Use of Static Test Stand at Edwards Air Force Base.	Provides for NASA to be tenant at Edwards with right to exercise operational control and responsibility over assigned facilities in support of Centaur program; Air Force to provide support and services without reimbursement with exception of certain technical services.
30	do.	NASA-Navy.....	Navy Use of NASA Langley Research Center.	Provides for Navy use of hydrodynamics research facility at Langley; Navy to have complete use of 1 tank.
31	Jan. 16, 1961	DOD-NASA.....	Space Surveillance of U.S. and Foreign Satellites and Space Vehicles (classified).	Outlines performance of functions relative to national space surveillance of artificial objects in space.
32	Feb. 14, 1961	NASA-Air Research and Development Command.	Agona B Launch Vehicle Program.....	Provides for NASA-modified Agona B launch vehicle program; direct contact and liaison between NASA representatives and Air Force personnel and contractors; NASA representative on Agona Configuration Control Board.
33	Feb. 23, 1961	DOD-NASA*.....	National Launch Vehicle Program.....	Makes provision for development and procurement of launch vehicles by separate agencies for mutual use; agreed that DOD and NASA will not initiate development of space launch vehicles or boosters without mutual consent; delegates specific interagency planning responsibilities to AACB.
34	Mar. 15, 1961	NASA-Army.....	Transportation Support for U.N. Conference.	Provides for transportation services by Army to NASA for United Nations Conference on Peaceful Uses of Outer Space.
35	Mar. 21, 1961	do.....	Surveys of Armed Services Explosives Safety Board.	Authorizes Armed Services Explosives Safety Board to assist NASA in surveys of installations and in advising NASA personnel on proper techniques for handling of solid propellants.
36	Mar. 23, 1961	Air Force-NASA.....	Modification and Construction of Atlas Launch Stands.	Provides for cooperative program to modify existing Atlas launch stands and construct an additional stand in support of Agona, Mercury, and Centaur projects; funding to be shared by both agencies.
37	Mar. 28, 1961	do.....	Launch Stand Loading Schedules, Pacific Coast.	Modifies agreement of Feb. 23, 1960, to include launch facilities at Point Arguello and Vandenberg Air Force Base.
38	July 7, 1961	NASA-DOD.....	Range Radio Frequencies.....	Provides for close coordination on use of radio frequencies for launch and range support activities; DOD lead ranges given primary responsibility for certain frequency matters.

39	Aug. 11, 1961	NASA-DOD.....	Synchronous Communications Satellite.....	Provides for NASA use of DOD Project Advent resources for NASA Syncom project toward joint objective of early application of technology for commercial and military purposes; commits NASA to \$15,000,000 in fiscal year 1962 and DOD to \$10,000,000.
40	Aug 15, 1961	NASA-Air Force-Navy.....	X-15.....	Upon completion of initial phase of X-15 flight research, agreed that follow-on program be instituted; assigns to Joint Program Coordinating Committee responsibility for formulating new program.
41	Aug. 24, 1961	DOD-NASA*.....	Launch Site for Apollo Program.....	Provides for new launch facilities for Project Apollo in Cape Canaveral area; agreed that national interest requires pooling of resources to make effective use of Atlantic Missile Range; DOD and NASA to continue range-operator/range-user relationship; new launch site to be operated as joint venture under single management to prevent duplication and promote efficiency; NASA to pay for land and improvements; Air Force assigned management responsibility for all "range operations"; Air Force as NASA agent to accomplish master planning and arrange for design and construction; NASA responsible for design and operation of NASA mission facilities and equipment.
42	Oct. 12, 1961	Naval Weapons Plant-NASA.....	Assignment of Facilities to NASA.....	Provides for host-tenant relationship at Naval Weapons Plant, Washington, D.C., on reimbursement basis.
43	Nov. 28, 1961	DOD-NASA*.....	Integrated Launch Vehicle Program (classified).	Reaffirms concept of integrated national launch vehicle program and necessity to avoid single mission-oriented launch vehicle developments.
44	Dec. 6, 1961	DOD-NASA*.....	Titan III Development Program (classified).	DOD to develop solid strap-on Titan III launch vehicle; Titan II missile to be modified for Mercury II (later called Gemini) rendezvous mission.
45	Jan. 24, 1962	DOD-FAA-NASA.....	Declassification Procedures.....	Establishes compatible interagency regulations for implementation of Executive Order 10601, as amended.
46	Mar. 31, 1962	DOD-NASA*.....	Overflight.....	Agreement by which NASA and DOD accept the safety risks of overflight of new launch facilities near Cape Canaveral in the interest of land use economy; confirms responsibility of Commander, Atlantic Missile Range, for launch pad siting, range safety, and master planning.
47	Apr. 17, 1962	Navy-NASA.....	Navy Field Services for NASA.....	Makes provisions for Navy to perform field service functions in connection with NASA contracts performed in plants serviced by Navy representatives; NASA to maintain technical direction of its contracts; reimbursement based on actual man-hours expended for NASA; NASA contracting officers authorized to assign directly to Navy inspection offices the responsibility for performance of field service functions.
48	Apr. 18, 1962	NASA-Navy Bureau of Yards and Docks.	Navy Design and Construction Services for NASA.	Establishes procedures by which Navy Bureau of Yards and Docks may perform design and construction services for NASA at range sites of Atlantic and Pacific Missile Ranges and elsewhere; gives NASA authority to make requests directly to Bureau of Yards and Docks; NASA to obtain real property rights; reimbursement to be made on the basis of project costs.

No.	Date	Parties	Subject	Description
49	May 28, 1962	DOD-NASA	Agema D	Implements agreement of Feb. 23, 1961; NASA and DOD agree that development by DOD of standardized Agema D stage for joint use with Atlas and Thor first stages should be undertaken to meet objectives of national launch vehicle program.
50	June 21, 1962	NASA-DOD	Scout	Details responsibility, authority, and interagency relationships for NASA-DOD Scout vehicle system; objective is standardized system; establishes strict configuration controls; program monitored by Joint Coordinating Committee; NASA is lead agency for system; Air Force responsible for launch operation and maintenance of Scout system at Pacific Missile Range.
51	July 27, 1962	DOD-NASA	Gemini program	Continues support arrangements by DOD for NASA used in Project Mercury; confirms streamlining of management arrangements with respect to relations between NASA Marshall Center and Air Force Space Systems Division on the acquisition of Agema stage, developed by Air Force.
52	Aug. 7, 1962	NASA-Air Force	Dyna Soar	Supersedes agreement of Dec. 14, 1958; confirms objective of Dyna-Soar program in exploring problems and potentials of highly maneuverable manned reentry vehicle capable of hypersonic speeds and conventional landing; NASA endorses objective as necessary to national aerospace program; Dyna-Soar to continue as Air Force program with technical testing support by NASA.
53	Oct. 30, 1962	DOD-NASA*	Large Solid Propellant Motor Program [classified].	Air Force to conduct advanced technology program in very large solid propellant motors; program not linked to any specific vehicle schedule requirement.
54	Nov. 28, 1962	AEC-NASA-DOD*	Nuclear Electric Space Power Unit	Establishes authorities and responsibilities of parties in research and development of advanced nuclear electric space power unit designated SNAP-50/SPUR; recognizes significant performance potential in nuclear space power systems; AEC responsible for development of power unit including integration of reactor and nonnuclear components; Air Force to establish military requirements and to provide project support including flight tests; NASA to provide supporting design data information; AEC program office to be headed by Air Force member assigned to AEC with NASA deputy; funding in accordance with separate agency responsibilities.
55	Nov. 28, 1962	Army-Navy-Air Force-ARPA-NASA.	Interagency Chemical Rocket Propulsion Group.	Group established to exchange information at technical levels with the objective of increasing the effectiveness of total interagency chemical propellant and rocket propulsion program; Navy to administer contract for operation of Propellant Information Agency.

56	Dec. 10, 1962	DOD-NASA	Standard Atlas Space Booster Program [classified].	Conforms with Feb. 23, 1961, national launch vehicle program agreement; agreed that Air Force to develop standard Atlas booster for joint NASA-DOD use.
57	Dec. 13, 1962	NASA-DOD	Project Anna	DOD to continue project management of Anna I and provide certain ground tracking and preliminary data processing for follow-on program; NASA to manage and fund follow-on geodetic satellite program.
58	Dec. 19, 1962	Army-NASA	Apollo Spacecraft Propulsion Development Facility, White Sands Missile Range.	NASA to use portion of White Sands Missile Range for construction and operation of a propulsion development facility for Apollo program; NASA to be tenant of Army; all permanent facilities to become property of Army upon termination of use by NASA; NASA responsible for own support services in its area; Army responsible for range safety and management.
59	do	do	White Sands Missile Range Support of NASA.	Provides for NASA use of range except as provided under separate Mercury and Apollo agreements; common service not subject to reimbursement; reimbursement for cross-servicing support such as photography, overtime, field printing, construction and maintenance required for direct support of NASA, and expendable supplies and repair parts.
60	Jan. 14, 1963	NASA-DOD	Management of NASA Merritt Island launch area and DOD Atlantic Missile Range.	Supersedes agreement of Aug. 24, 1961; provides that Merritt Island launch area to be operated as a NASA installation, separate and distinct from Atlantic Missile Range; NASA responsible for master planning and development of Merritt Island and to act as host agency at Merritt Island for providing of facilities and services to DOD; DOD to be host at Cape Canaveral and elsewhere on AMR; DOD to continue responsibility for operation and management of range facilities of AMR as national asset, providing common range services to DOD and NASA; DOD and NASA to keep each other fully informed on plans and requirements; joint consultation required to achieve instrumentation compatibility.
61	Jan. 21, 1963	NASA-DOD*	Gemini	Agreed that Gemini experiments to be directed at the objectives and requirements of DOD and NASA; establishes Gemini Program Planning Board reporting jointly to Administrator of NASA and Secretary of Defense; Board to plan experiments for NASA and DOD requirements; NASA to continue Gemini project management; DOD to participate in development, pilot training, preflight checkout, launch operations, and flight operations; DOD to contribute funds as later agreed upon; "further agreed that the DOD and NASA will initiate major new programs or projects in the field of manned space flight aimed chiefly at the attainment of experimental or other capabilities in near-earth orbit only by mutual agreement."
62	Feb. 2, 1963	DOD-NASA	Nonmilitary Applications of Transit Navigation Satellite System.	NASA responsible for governmental determination of suitability of Transit navigational equipment to meet nonmilitary navigation requirements and to be responsible for development of such equipment; Navy to provide information and completed military units to NASA on reimbursable basis; Navy and NASA to coordinate for mutual benefit of both military and nonmilitary programs and to avoid unnecessary duplication.

No.	Date	Parties	Subject	Description
63	Apr. 13, 1963	DOD-NASA.....	Agema D.....	Supplements agreement of May 29, 1962, which provided for single basic vehicle to meet requirements of both agencies; new agreement covers program to effect weight reduction of basic Agema D vehicle to permit increased payload for NASA and DOD program; supplementary program to be directed by Air Force with NASA participation; NASA and Air Force to share equally \$2,600,000 development cost.
64	Aug. 22, 1963	NASA-DOD*.....	Thrust Augmented Delta (TAD).....	Conforms with Feb 23, 1961, agreement requiring mutual consent before launch vehicle or booster development; TAD program to integrate existing thrust-augmented Thor into existing Delta launch vehicle to provide reliable, versatile, and economical capability for DOD and NASA space missions.
65	Sept. 14, 1963	DOD-NASA*.....	Possible New Manned Earth Orbital Research and Development Project.	Agreement that national space program may require operation of advanced manned orbital system; stipulates that advanced exploratory studies and follow-on actions in this area to be carefully coordinated through AACB; further agreed that insofar as practicable such a system should be a single project; system to be capable of prolonged space flight providing basic scientific and technological knowledge and basic design and operational design criteria having application to both military and civilian operational programs; developmental system to be mandatory forerunner of any long-duration manned space operational system; after AACB review, Secretary of Defense and Administrator of NASA to make joint recommendation on new project and formulate project description for submission to President, together with recommendation as to agency responsible for direction of project; specifies maximum practicable interchange of ideas and information at all levels within the 2 agencies beginning early in the conceptual or planning stage.
66	Nov. 8, 1963	NASA-Army Corps of Engineers...	Real Estate Management.....	Upon request, Corps will prepare land use plan for approval of NASA; NASA to determine when certain real property interests are not required for a NASA program and can be made available by lease or otherwise to public or private entities; such grants to be executed by Corps of Engineers.
67	Nov. 27, 1963	NASA-MSTS.....	Ocean Transportation for Large Saturn Stages.	MSTS to provide ocean transportation service to NASA for large Saturn stages on reimbursable basis; MSTS to make necessary ship modifications with reimbursement by NASA; MSTS to utilize ships for other purposes when scheduling permits with earnings to be offset against costs billed to NASA.
68	Dec. 5, 1963	NASA-DOD.....	AMR Funding.....	Based on recommendation of Joint Funding Board, agreed that present funding arrangement at Atlantic Missile Range shall remain in effect; agreement of Jan. 17, 1963, had asked for determination as to whether NASA should provide to DOD a pro rata share of AMR costs based on the relationship of NASA program workload to total workload.

69	Jan. 15, 1964	DOD-NASA*.....	Instrumentation Ships.....	To avoid costly duplication, agreed that instrumentation ships required to support the programs of NASA and DOD will be placed in pool operated by DOD in behalf of both agencies; establishes management and operation procedures with NASA participation; Navy to be lead agency on ship modification and conversion; MSTS responsible for ship operation; DOD range agencies responsible for scheduling and instrumentation operations.
70	Feb. 4, 1964	DOD-NASA.....	Utilization of Idle Industrial Plant Equipment.	Supersedes and updates agreement of Nov. 25, 1958.
71	Apr. 5, 1964	DOD-NASA.....	Geodetic Satellite Program.....	Parties concur in conclusions of Bureau of the Budget; no change made in arrangement by which NASA responsible for conduct of national geodetic satellite program to meet requirements of all agencies; NASA and DOD to strengthen interchange of program management information at responsible central management levels of both agencies; specifies feasible national program and schedule.
72	Apr. 20, 1964	DOD-NASA.....	Contract Administration Services in Pilot Philadelphia Region Program.	Supersedes existing agreements with respect to contract administration services support within Philadelphia region (Project 60); DOD to perform field contract administration services in support of NASA-placed contracts; amended Oct. 15, 1964, with respect to reimbursement details.
73	do.....	DOD-NASA.....	Lunar Mapping and Survey program.....	Air Force to provide technical assistance to NASA by developing and providing manned lunar mapping and survey flight equipment to meet NASA requirements; NASA to make contractor selections and develop equipment; general management by joint NASA-Air Force team; NASA to transfer sufficient funds to Air Force.
74	May 14, 1964	Air Force-NASA.....	Common Item Supply for Cape Kennedy and Merritt Island.	Air Force responsible for common item support at Cape Kennedy Air Force Station and NASA at Merritt Island; manpower authorizations and reimbursement procedures to be determined at later date.
75	June 15, 1964	do.....	Loan of Aircraft to NASA.....	Air Force loans to NASA 2 C-121G aircraft for Project Gemini; loan to expire Aug. 1, 1966; no reimbursement provisions.
76	June 17, 1964	NASA-Air Force.....	Industrial Facilities Support.....	Supersedes agreement of Aug. 15, 1959, as revised Sept. 15, 1960; sets forth instructions and guidance for industrial facilities support of NASA contracts; new facilities required at Air Force administered plants for performance of NASA contracts to be provided by NASA; Air Force to maintain custody of DOD-owned industrial plants used by NASA; where NASA or Air Force have provided facilities to a contractor either may use such facilities on separate contracts on a no-charge, noninterference basis; all field service functions performed by Air Force for NASA to be subject to reimbursement agreements.

No.	Date	Parties	Subject	Description
77	June 30, 1964	NASA-Air Force.....	Recovery of NASA Biosatellite.....	Air Force to provide airborne recovery system and conduct recovery of biosatellites; funding estimates to be submitted to NASA for reimbursement.
78	July 16, 1964	Navy-NASA.....	Reimbursement Principles for Navy Recovery Operations.	NASA to reimburse Navy for manned space flight recovery operations, including ship-days, aircraft-hours, special equipment, administrative expenses, and medical assistance.
79	Aug. 21, 1964	NASA-DOD.....	Research and Technology Information Exchange.	Provides for exchange of standard set of information on research and technology projects in order to improve knowledge of each other's work and to achieve program balance; creates standard reporting form, research and technology resume, NASA form 1122 and DOD form 1498, superseding previous R.D.T. & E. project cards such as DD form 613.
80	Sept. 10, 1964	Treasury-Defense-Interior-Commerce-FAA-NASA.	Nonmilitary Navigation Satellite System.	Establishes ad hoc Joint Navigation Satellite Committee to determine and evaluate requirements for satellite system to meet future needs in air and sea navigation, air and sea traffic control, air-sea emergency and rescue activities, and related data transmission; committee also to recommend appropriate development program including the method and organization of such program.
81	Sept. 15, 1964	NASA-Air Force.....	Detail of Air Force Officers to NASA.....	Supersedes agreement of Sept. 30, 1959; establishes new criteria for assignment of Air Force officers; restricts NASA requests to positions requiring education, experience, or skills especially developed by Air Force in fields of technical program management, engineering, and physical or life sciences; NASA to make reasonable effort to fill positions from civilian sources prior to making a request to Air Force; Air Force officers in grade of captain and above to have minimum of 3 years potential Air Force service upon completion of NASA assignment; officers below the rank of major to be nominated only if position offers exceptional opportunity for Air Force.
82	Sept. 25, 1964	Air Force-NASA.....	Assignment of NASA Personnel for Duty With Air Force.	Provides for detail of NASA employees to Air Force; requests to be made for personnel in rank of GS-13 or higher; duty assignment to provide NASA employee with experience of benefit to NASA upon return; normal tours of duty to be 2 years.
83	Oct. 7, 1964	NASA-DOD.....	Geodetic Explorer Project Program Plan.	Provides for program plan for geodetic satellite project to fulfill requirements of NASA, DOD, and Department of Commerce, and allows for international cooperation.
84	Oct. 23, 1964	NASA-DOD.....	Early Gravity Gradient Tests.....	Provides for early gravity gradient tests in Defense communications satellite program to provide data for advanced defense system; test plans to be developed jointly; DOD responsible for source selection; NASA to transfer up to \$5,000,000 in funds.

85	Nov. 10, 1964	NASA-Air Force.....	Loan of Aircraft to NASA.....	Provides for loan of aircraft to NASA in support of astronaut space flight readiness training at Manned Spacecraft Center, Houston, Tex.
86	Dec. 28, 1964	DOD-NASA.....	Delta Launch Facility at Western Test Range.	Establishes Delta launch vehicle capability at DOD Western Test Range; NASA to develop improved configuration of Delta launch vehicle; DOD to phase out Thor-Ablestar and use Delta in its place; Air Force to procure Thor 1st stage and chair Configuration Control Board with NASA representation; NASA to procure Delta upper stages and chair Configuration Control Board with Air Force representation; launch pad and blockhouse to be used for Delta launches on shared basis with schedules set by joint committee; NASA to exercise launch vehicle control over all Western Test Range launches.
87	Dec. 31, 1964	NASA-DOD.....	Transfer of Syncom II and III to DOD....	Provides for transfer of complete control of NASA synchronous communications satellites, Syncom II and III, to DOD, together with telemetry and command equipment; DOD to refer all requests for commercial use of satellite to NASA; no reimbursement provisions.
88	Dec. 28, 1964	NASA-DOD.....	Establishment of Titan III-X-Agena as Standard Launch Vehicle (classified).	Modification of Titan III introduced as member of standard space launch vehicle family; Titan III-X to accommodate Agena or other upper stages.

SEPARATE VIEWS OF HON. PORTER HARDY, JR.

This report's factual recitation of the development of our space effort should be very useful. The great pressures for accelerating achievement in our civil-military space effort have hampered precise and orderly planning. The trial and error beginning period should now be behind us, and there is need for any agency structure which will encourage the maximum and orderly development of our space program. This report can be helpful toward this objective; for, as far as I know, it is the only document which gives such a current, comprehensive picture and identifies so many of the specific problems which must be solved.

I do not, however, subscribe to the report in its entirety. In my opinion it contains a weakness, particularly in the evaluation of some of the facts which have been developed and the conclusions adduced from those facts. Certain conclusions are, I believe, much too broad. For example, I know of no evidence which supports the unqualified conclusion that "the Soviet Union is substantially ahead of us" in the military space field. If such a conclusion had been limited to the Russian accomplishments in manned spacecraft it might be valid, but I seriously question its accuracy when applied comparatively to our overall military space development.

I have a more fundamental disagreement with the approach which the committee has taken in connection with certain recommendations. The committee has assembled a considerable volume of important data concerning manned space activity and its potential military use. Certainly the attention of the Department of Defense needs to be directed to this. Additionally, the committee might most appropriately call it to the attention of the Committee on Armed Services, with the suggestion that that committee consider policy decisions to increase emphasis on such manned space effort as the MOL project. However, I question the propriety of the first sentence in recommendation No. 1 as a policy declaration by the Committee on Government Operations. It would, of course, be entirely appropriate for each member of the committee, if he has this conviction, to express it as an individual member. But I consider that in making this recommendation, the Committee on Government Operations has exceeded its authority under the House rules.

With respect to some of the report's comments concerning NASA, it might have been more appropriate for the Committee on Government Operations to suggest that the Committee on Science and Astronautics consider policy questions involved.

With respect to recommendation No. 3, I applaud the emphasis on orderly planning, but I question the wisdom of the method suggested to achieve this end. It occurs to me that the members of the National Aeronautics and Space Council (whose members include the Vice President, the Secretary of State, and the Secretary of Defense) would have even less time to get into the "sticky details" of coordination than do the members of the Aeronautics and Astronautics Coordinating Board. It, therefore, seems to me that the recommendation would re-

sult in the delegation or transfer of the bulk of the decisionmaking processes to a staff apparently to be formed for this purpose. If the end sought is "a dynamic agency" and a "leadership instrument for an integrated national space effort," perhaps this can be better achieved by giving the Board the "built-in decisionmaking power" which the report states is presently lacking.

I am in agreement with the basic purpose of recommendation No. 10 if it is aimed at the DOD directive on security policy for military space programs. That document is a blanket blackout which causes a complete loss of identity of the military space effort. It even denies information to Members of Congress unless they have special access clearance. Although I support whatever security measures are necessary to our national defense, I feel that security should be imposed rationally on a case basis. I believe it would, therefore, be well to have a review of this entire problem, and this should be done by the appropriate committee.

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