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EXECUTIVE
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THE VICE PRESIDENT
WASHINGTON

May 17, 1967
1:30 p.m.

MEMORANDUM

FOR: The President

FROM: The Vice President HH.

SUBJECT: Air Space vs. Outer Space

Discussion of the recent Space Treaty has again raised the issue of where air space ends and outer space begins. The French at the UN have requested that this question be put on the agenda of the Legal Subcommittee of the UN Committee on the Peaceful Uses of Outer Space.

To obtain a coordinated view of agencies primarily concerned with this question, Ed Welsh held a meeting with the General Counsels or equivalent officials of State, Defense, Transportation, NASA, AEC, FAA, CIA and USIA.

They recommended unanimously that the United States position be that no definition of air space or outer space should be made at this time. The accompanying memorandum explains this situation in more detail. I have sent a copy of it to the Secretary of State for his information.

I submit that the conclusions arrived at seem reasonable.

5/18/67
6 pm

Enclosure

April 26, 1967

COPY

MEMORANDUM FOR THE VICE PRESIDENT

Subject: Air Space vs. Outer Space

In my March 29 memorandum, I advised that the Space Treaty had again surfaced the questions of how high from the earth's surface air space extends and where outer space begins.

In response to my inquiry, you advised that staff level study should precede placing the issue on a Space Council agenda. The subject has now been studied and an interagency meeting of General Counsels has been held with the Space Council staff.

Representatives from the following agencies attended and participated at my invitation: State, Defense, Transportation, NASA, AEC, FAA, CIA, and USIA.

In opening the meeting, I expressed your interest and stated that the purpose was to explore and discuss the question of air space vs. outer space, and, in particular, to determine whether such definition at this time was in the best interest of the United States.

I reminded the group that in 1962 the Space Council had examined the question of whether the U. S. should propose an upper limit to air space and, if so, what such limits should be. The conclusion reached at that time was that it was neither necessary nor desirable to commit this country to a definition of air space or outer space. Furthermore, I pointed out that the Chicago Convention on Civil Aviation in 1944 had established complete and exclusive national sovereignty over air space but had identified no specific limit or altitude to which that air space would extend. The Space Treaty does not define outer space, although we have agreed to study the question of definition at the forthcoming meetings of the Legal Subcommittee of the U. N.

At this most recent interagency meeting, it was concluded that there was no need to formulate any definition of air space or outer space at this time, and that in fact there might be unnecessary problems created by such definition. Those assembled at the meeting agreed to this position without any dissent.

In response to an inquiry as to what should be said if question is raised about the definition of air space and outer space, it was agreed that it would be most appropriate for statements to be made by our representatives at the U. N., and that the position taken would be generally: (1) that we should treat as air space those levels at which air-breathing aircraft operate now and in the future; (2) that outer space would be that area in which satellites can orbit the earth as well as all the area beyond that; and (3) that the zone between those two operating regimes would continue to be a subject for study.

I believe this meeting had a satisfactory conclusion and that the position taken by the participants was a reasonable one. While the subject can be put on a Space Council agenda, it might be only necessary to report the results of this interagency examination.

You may want to advise the President of this situation. If there is anything I should do to help you in that regard, please let me know. Likewise, I can send copies of this memorandum to the Council members, if you believe it would be advisable.

E. C. Welsh

Mw

EXECUTIVE
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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE SECRETARY

May 19, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space and Aeronautics Activities

1. Launches

a. The Soviet Union launched Cosmos 157, 158, 159, and 160 on May 12, 15, 16, and 17 respectively. Cosmos 157 was placed in a low-altitude orbit from which recovery normally takes place after eight days. Cosmos 158 was put into a 500-mile circular orbit; 159 into a highly elliptical orbit with an apogee of 37,500 miles and a perigee of 230 miles; and 160 into a low-altitude orbit.

b. The Department of Defense launched a classified satellite into orbit from Vandenberg AFB on May 18, using a Scout vehicle.

2. Surveyor. NASA's Surveyor III spacecraft began warming up on May 18, with the coming of the lunar dawn. Its batteries, frozen during the two-week lunr night, will be warmed until May 23, when attempts will then be made to use again the camera and soil-sampling devices.

3. Lunar Orbiter. Earlier troubles with the thermal door that covers the camera lens have been remedied. Photographs transmitted are excellent, one showing an earthquake-type fault about 200 miles long and 10 miles wide in the southern polar region of the Moon.

4. Nuclear Detection. Sensors were successfully turned on May 12 aboard the two Vela nuclear explosion detection satellites launched on a Titan III-C April 28.

5. Congress

a. The House Committee on Science and Astronautics is preparing its report on the NASA Authorization. The Committee will recommend an Authorization of $4,992,182,000 -- a reduction of some $108 million from the Agency's request for $5.1 billion. The Committee proposes to cut Manned Flight by $46.8 million, Space Sciences by $35.4 million, and Advanced Research by $25.7 million. This is an over-all cut of about 2%.

b. The Independent Offices Appropriation Bill, which included the Space Council budget request of $524,000, was approved by the House by a vote of 347 to 56 on May 18. The NASA appropriation, delayed by the Apollo accident investigation, will be handled after the Authorization is passed.

6. Apollo Applications Program

a. NASA is now in the process of defining a more extensive Earth-orbital Apollo Applications Program. Included in the new planning is a reorganization of responsibilities.

b. The Saturn S-IVB stage "orbital workshop" mockup is being used at Marshall Space Flight Center for outfitting and designing the set of experiments currently being planned for the AAP Office. Close coordination exists between this effort and the Air Force MOL program.

c. NASA will fund ESSA's development of an advanced infrared sensor to detect surface and vertical temperatures of the atmosphere. It may be used in the Apollo Applications Satellite program, which is scheduled for launch in mid-1969.

7. Astronomy. Data obtained following an Aerobee sounding rocket launch at the White Sands Missile Range indicates that the Earth's galaxy is relatively old compared with many of the other galaxies in the universe. The judgment of age was based on the amount of molecular hydrogen present between the Milky Way's stars.

8. Spinoff. Scientists at the California Institute of Technology are using a lunar seismometer developed for the Ranger program to obtain information for designing earthquake-proof structures such as skyscrapers and power dams. They are also employing data gained in the design of spacecraft and boosters to determine the integrity of man-made structures during earthquake vibrations.

9. Pending Launch. NASA's Fifth Interplanetary Monitoring Platform (IMP) is scheduled to be launched from the Western Test Range aboard a Delta booster no earlier than May 24 for further study of solar events.

10. Space Payload Success Box Score

(May 19)

	U. S.		U. S. S. R.	
	1966	1967	1966	1967
Earth Orbit	28	30	19	24
Escape	0	3	2	0

Time: 11:30 a. m.

E. C. Welsh

EXECUTIVE

OS
FG 11-4

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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE SECRETARY

May 12, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space and Aeronautics Activities

1. Lunar Orbiter. On May 8, Lunar Orbiter 4 fired a braking rocket which placed the spacecraft in a lunar polar orbit suitable for the photographic mapping of almost 90% of the lunar surface. High quality picture-taking was initiated May 11.

2. Apollo Plans. NASA has advised both the Senate and House Space Committees that the following steps have been undertaken to increase safety and get the Apollo program back on the track: (a) first Apollo manned launch for early next year; (b) crew of Schirra, Cunningham, Eisele; (c) continuation of 100% oxygen atmosphere, with elimination of most flammable material; (d) quick-opening hatch to Apollo command module; (e) no increase in funds needed for the plan; (f) eleven Saturn V flights before end of 1969, with hope that the manned lunar trip can be accomplished in that time span; (g) contractors' arrangements, with North American doing the standardized Apollo, Boeing the integrating of Saturn and Apollo, and a third yet unmanned contractor to work on Apollo Applications.

3. MOL Review. The Air Force is carefully reviewing with the Aerospace Corporation and their contractors, the status of their design and material selection for the Manned Orbiting Laboratory (MOL). Of particular concern are those things that could be contributory to a fire once ignition had started and the design location of ignitable materials.

4. Launches

a. The Department of Defense placed a satellite into orbit on May 10 from the West Coast, using a Thor Agena launch vehicle.

b. The British satellite Ariel III was successfully launched by a NASA Scout vehicle from the West Coast on May 5. This was the first orbited U. K. constructed spacecraft. It was put into a near circular polar orbit and now is making measurements of the upper layers of the ionosphere.

5. Papal Pilgrimage. Pope Paul VI's pilgrimage on May 13 to the Shrine of Our Lady of Fatima in Portugal will be carried live by two U. S. television networks by way of the EARLY BIRD satellite.

6. Aeronautics

a. M-2 accident. On May 10 the wingless experimental aircraft M-2, designed as a lifting body reentry vehicle from spaceflights, crash-landed as it returned to Edwards Air Force Base. The pilot was not critically injured, but the craft was extensively damaged. This was the first accident and the sixteenth unpowered drop of an M-2 from an aircraft, the third for this pilot.

b. VTOL Accident. On May 10, two pilots were killed while operating an experimental vertical takeoff aircraft near Dallas. Five of these XC-142A airplanes have been built and one is scheduled for exhibition at the Paris Air Show.

c. F-111 Contract. On May 10, the Department of Defense announced it had signed a contract with General Dynamics to produce 493 F-111 airplanes.

d. SST Prospects. Recent estimates have indicated that the SST will be more economically successful than the Concorde, current subsonic jets, and possibly even the jumbo jets.

7. U.S.-U.S.S.R. Weather Cooperation

a. The Soviets have advised the World Meteorological organization that their Cosmos 144 and 156 weather satellites now constitute an operational system. Up until now the Soviets have categorized their efforts in this field as experimental.

b. U. S. weather officials are making efforts to procure high-speed U. S. weather terminal communications equipment for the Moscow end of the cold line in order to speed up the exchange of conventional and satellite data to a near-real-time basis.

c. The Soviets have agreed to discuss coordinated use of operational weather satellite systems at a World Weather Watch meeting to be held in Geneva in September 1967.

8. Aerospace Industry Profits. In spite of large gross sales, net income of 32 major aerospace companies for the first quarter of 1967 was down

an average of 21 percent from the first three months of 1966. This compares with average earnings decline of 9 percent for a sample of 1073 manufacturing companies.

9. Space Payload Success Box Score
(May 12)

	U. S. 1966	U. S. 1967	U. S. S. R. 1966	U. S. S. R. 1967
Earth Orbit	24	29	19	20
Escape	0	3	2	0

E. C. Welsh

Friday, May 12
Time: 11:00 a. m.

JMT/

EXECUTIVE
OS
IT 47-26

May 9, 1967

FOR Arthur Goldberg

FROM Joe Califano

Attached is a possible speech for ~~Senator~~ Mike Mansfield on the President's record on space.

Would you please write your comments on it and return it to me?

Nothing else sent to
Central Files as of 7/28/67

PRESIDENT JOHNSON MOVES AMERICA FORWARD
IN THE WORLD SPACE AGE

On April 25th the United States moved dramatically forward in the World Space Age.

That was the day the Senate unanimously ratified the first Outer Space Treaty.

It was an historic event. And the proudest man at that moment must have been President Lyndon B. Johnson. For he, more than any other American, moved this country -- and, indeed, the world -- into the Age of the peaceful international exploration of space.

In February 1967, when the President submitted the treaty to the Senate -- already signed by more than half the nations of the world -- he said: "In the next decade and in the decades to come, the capabilities of nations in space will multiply far beyond our comprehension today. If we should flag or falter in our support of this great extension of human knowledge, the concern and anxiety we felt so keenly a decade ago would be known again to other Americans."

"The future leaves no option. Responsible men must push forward in the exploration of space . . . . Their voyage must be made in peace for purposes of peace . . . . This Treaty is a step. . . . toward assuring the peace essential for the long journey."

It had been, indeed, a long journey, but Lyndon Johnson has been on that journey from its beginning to its most recent successful achievement in the adoption of the Outer Space Treaty.

That Treaty, as you know, provides -- among other guarantees -- that all signatories shall share in the benefits of space exploration; that weapons of mass destruction shall not be used or tested in outer space; that astronauts shall be protected; and that all nations shall share the knowledge gained from peaceful space exploration.

But the stark technical words of a Treaty cannot possibly describe the vision, emotions and efforts which made it into a reality over a period of years. We must look back to the record of history to see how the vision and determined energy of Lyndon Johnson persisted as he dreamed his great dream of American space exploration and development.

Long before he was President, Lyndon Johnson was one of the first of our national leaders to recognize the importance of space exploration as an international goal as well as a national goal.

A month after the dramatic orbiting of the first Russian Sputnik, in 1957, Lyndon Johnson as Chairman of the Senate Preparedness Subcommittee took the initiative and led the first Congressional hearings into the status of the United States Satellite program which resulted in our Government's new comprehensive space research effort.

When the hearings were completed, a 17-point action program was unanimously recommended. It urged a vastly stepped up space and missile program. In the Committee's report, Chairman Johnson pointedly said: "Our position in space is determined by our capacity to use it, not by the acquisition of or defense of space's terrain. This is the special urgency of our space adventure. Space has given priority to a new denominator of national strength: the human mind."

He did not retreat in shock at Russian space achievements. He moved forward. He demonstrated his faith in America's space capabilities by telling an audience that same year: "The work and faith of men of science over the ages have brought us to the greatest challenge in our history. It is a challenge which we share and will accept joyfully -- as men and women who are willing to dare the vastness of outer space."

Indeed, that very year the skills and talents of the American mind were organized into the National Aeronautics and Space Administration which owed its birth -- in good part -- to the determined and far-seeing work of still another Johnson Committee.

That same Committee which recommended establishment of NASA also initiated an extensive study of space law. That study demonstrated its immense practical value ten years later with the approval of the Outer Space Treaty proposal.

But this was only a fraction of President Johnson's prodigious space efforts. He was constantly advocating international cooperation in space efforts. In hearings held before the Senate Special Committee on Space and Aeronautics in 1958, he said:

"Our ideal should be to convert outer space into a blessing for mankind, rather than a threat of the destruction of civilization."

In that same year, at the request of a Republican President and his Secretary of State, Majority Leader Johnson made an historic address to the United Nations on the peaceful uses of outer space. He urged immediate international cooperation in outer space. He said to the assembled diplomats of the world:

"Today, outer space is free. It is unscarred by conflict. It must remain that way."

'We know the gains of cooperation. We know the losses of the failure to cooperate . . . . If however, we proceed along an orderly course of full cooperation, we shall by the very fact of cooperation, make the most substantial contribution toward perfecting peace."

To look back over his achievements, we must say Lyndon Johnson was the single man most responsible for developing United States national space goals and for achieving those goals.

As Vice President of the United States, and Chairman of the Space Council -- the first Vice President ever assigned that responsibility -- he was responsible for fostering our lunar exploration program and perfecting a communications satellite policy.

He recommended requests for additional funds to accelerate America's large rocket booster program.

He recommended action on development of supersonic transport planes, a program which has begun to bear fruit under his guidance as President.

He was instrumental in formulating and supporting budgetary requirements which have guaranteed America's preeminence in every phase of space exploration and space cooperation.

A decade ago the United States was not the leader in space exploration. Today it has that lead -- in numbers of orbiting satellites, in rockets, and space shots. But its most important lead is found in the depth and breadth of its program to use space peacefully, to use space <u>for</u> man and not against him.

This has been one of Lyndon Johnson's many legacies to the United States. I have watched him and worked with him as a colleague as he almost single-handedly pressed our space program forward.

Isaac Newton, the great 17th century natural scientist and philosopher, was reported to have said that he was able to see into the future because he had stood on the shoulders of those who came before him. It might be said of Lyndon Johnson that the American nation in the space age stood on his shoulders and looked into a future of understanding and peaceful space exploration and cooperation.

As a friend I admire him. As a colleague, I ask the Senate and the people to salute him.

EXECUTIVE

SP/05

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THE WHITE HOUSE
WASHINGTON

May 8, 1967

TO: MR. DREXLER

FROM: Dorothy Territo

I am attaching some summary papers and copies of the more important speeches on space. We thought perhaps you would find them interesting background documents for your meeting with Dr. Welsh next Tuesday.

I look forward to seeing you then.

FROM
THE WHITE HOUSE
WASHINGTON, D.C.

Mr. Arthur Drexler
Museum of Modern Art
11 West 53rd Street
New York, New York

AIRMAIL - SPECIAL DELIVERY

BB/

EXECUTIVE

OS

FG 11-4

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE SECRETARY

May 5, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space and Aeronautics Activities

1. Supersonic Transport. In accord with presidential decision, the Secretary of Transportation signed contracts for construction of two prototype test models of the U. S. Supersonic Transport (SST). On May 1, the Congress was sent a request for $198 million to finance the Government's share of the cost of the construction during FY 1968. The Government's SST investment over the next four years is expected to be about $1,144,000,000, or 90% of the total cost. If successful as anticipated, all of this investment is expected to be repaid. The first prototype model is scheduled to fly in 1970, and the aircraft is expected to enter commercial service in about 1974.

2. Lunar Orbiter. NASA's Lunar Orbiter IV was successfully launched from Cape Kennedy May 4 on an Atlas Agena vehicle. The spacecraft is scheduled to photograph more than 80% of the near side, and 90% of the far side of the Moon, for a nearly complete mapping of the Moon.

3. Surveyor. The Surveyor 3's movable claw was able to place several portions of the lunar surface so that they could be photographed through separate color filters, which will enable a color picture to be made from black and white photographs. The spacecraft will be inoperative during a two-week lunar night, and then attempts will be made to reactivate it.

4. Congress. The House Science and Astronautics Committee approved recommendations from its subcommittees that $32.5 million be cut from NASA's FY 1968 R & D budget for space science and applications and $5.7 million from the budget for advanced research and technology. It voted, however, to give NASA an unrequested $12 million for further experimentation on the 260-inch solid-fueled rocket. The full committee is still awaiting a report from the Manned Space Flight Subcommittee on its portion of the NASA budget request.

5. Nuclear Detection. The two Vela nuclear burst detection satellites, launched as part of a five-satellite package by a Titan IIIC on April 28, have been successfully positioned in a 60,000 mile circular orbit.

6. British Satellite. The UK scientific satellite was scheduled to be placed in a 342-mile circular polar orbit by a NASA Scout booster from

the Western Test Range on May 5. Mission of the 198-lb. spacecraft, the first completely British built payload, is to supplement and extend investigations of the ionosphere and atmosphere.

7. Weather

a. The Soviets on May 1 began transmission to the United States of weather photographs from Cosmos 156, which was launched April 27. Picture quality is identical with that of Cosmos 144 and, in general, is similar to that achieved by U. S. weather satellites in 1961.

b. The World Meteorological Organization has begun a program of international scientific cooperation looking toward reliable global forecasting of weather up to two weeks in advance. The program will involve use of satellites, drifting balloons, ocean buoys, high-speed communication systems and computers.

8. Aeronautics. In recognition of increased attention to aeronautical research, a new position of Deputy Associate Administrator for Aeronautics has been established by NASA within its Office of Advanced Research and Technology.

9. Technology Application. Results obtained from NASA studies on aircraft tire hydroplaning on wet runways have enabled state highway engineers to reduce skidding accidents on selected stretches of highways by 90%. All told, NASA's Technology Utilization Program has answered 8,223 inquiries in 1966 and furnished 54,000 copies of publications requested by industry. Annual membership fees paid by industry for information access total $402,000.

10. Communications. The French and German Science Ministers announced that France and West Germany will build an experimental communication satellite for launch some time in 1971 into a synchronous orbit. The satellite, "Olympia", should be ready to carry the 1972 Munich Olympic Games and is expected to cost approximately $75 million which includes two ELDO launch vehicles.

11. Space Payload Success Box Score
(May 5)

	U. S. 1966	U. S. 1967	U. S. S. R. 1966	U. S. S. R. 1967
Earth Orbit	24	26	17	20
Escape	0	3	2	0

Friday, May 5
Time: 11:00 a. m.

E. C. Welsh

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EXECUTIVE

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FO11-4

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE SECRETARY

April 28, 1967

MEMORANDUM FOR THE PRESIDENT

H

Subject: Space Activities

1. Soviet Space Fatality. Russian Cosmonaut Col. Vladimir Komarov was killed April 24 when his Soyuz 1 spacecraft crashed in its 18th orbit after its successful launch early April 23. TASS reported that the lines of the main parachute were fouled when the chute was opened at 23,000 feet and that Komarov perished when the spacecraft re-entered at very high speed. The existence of other difficulties during the flight should not be discounted, as the Kremlin announced that it was appointing a commission to investigate the circumstances of the accident. Although there was no official Soviet statement to support it, there was wide speculation that the Russians had planned to launch a second spacecraft to rendezvous and possibly exchange crew members with the first ship.

2. Other Launches

a. The DOD successfully launched April 28 a Titan IIIC from Cape Kennedy carrying two VELA (nuclear explosion detection) and three small radiation measuring satellites. The two VELA satellites will be placed into 60,000-mile 18-hour circular orbits. The three radiation satellites will remain in the highly elliptical 60,000-mile apogee and 4700 perigee orbit.

b. The Soviet Union announced on April 27 the launch of Cosmos 156, an unmanned scientific satellite. It said that the spacecraft was in a circular orbit at an altitude of about 390 miles and was functioning as planned.

c. The first satellite launched by Italy was put into orbit April 26 from a platform in the Indian Ocean off the coast of Kenya, Africa. The 45-pound satellite, instrumented to measure air density, was placed in equatorial orbit by a U. S. Scout launch vehicle. This was a cooperative project by the Italian and U. S. space agencies and was the first launch of a satellite from a sea platform.

3. Surveyor. NASA's Surveyor III, which landed on the moon April 19, successfully dug a series of trenches on the lunar surface--the most recent, on April 27, to a length of nearly two feet. Earlier, the robot claw of the soft-lander dug a 15-inch long trench 7 inches deep, finding pebbles at the 6-inch depth. The deeper the claw probed, the firmer the soil appeared to be, with a consistency indicative that it will hold a landing

spacecraft. The spacecraft photographed the Earth during an eclipse of the moon by the Earth, and it also photographed Venus. Some 2,880 pictures had been taken as of April 27.

4. Weather. Cameras on the ESSA V satellite, which was successfully launched into near-polar orbit on April 20, were turned on during the week and the pictures were excellent.

5. Outer Space Treaty. The Senate approved the Treaty on Outer Space by a vote of 88 to 0 on April 25. The ratification of the Treaty followed unanimous approval by the Foreign Relations Committee.

6. Aerospace Industry Growth. The U. S. aerospace industry continues to be the Nation's largest industrial activity. Sales have increased this year from $20.9 billion to $23.8 billion; employment from 1,250,000 persons to an estimated 1,384,000 for 1967.

7. Astronauts to Paris. Astronauts Michael Collins and David Scott will appear at the Paris Air Show next month. Scott flew in Gemini VIII and Collins in Gemini X.

8. Congress

a. The Senate Space Committee has completed its hearings on the NASA Authorization. The Committee seems to be taking a critical attitude toward new large projects which carry a long-term spending commitment.

b. The House Space Committee has completed its hearings on the NASA Authorization and plans to hold an executive markup session on May 2 on all portions of the authorization except that covering manned space flight, which latter is to be held up pending a NASA report as to the effect of the Apollo accident on the Apollo schedule and funding requirement. The Committee also made favorable recommendation on the 260" solid rocket engine.

9. Space Payload Success Box Score
(April 28)

	U. S. 1966	U. S. 1967	U. S. S. R. 1966	U. S. S. R. 1967
Earth Orbit	24	26	17	20
Escape	0	2	2	0

Friday, April 28
Time: 10:45 a. m.

E. C. Welsh

TELEGRAM-Incoming

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PASS COPIES CHRISTIAN ROSTOW

1. AMERICAN NEWS AND COMMENT. TUESDAY MOOD PAPERS FEATURE NEW AIR STRIKES HANOI HAIPHONG. WASHSTAR FRONTPAGES JOHNSON IN GERMANY. SOME COMMENT ON INCREASED BOMBING, ADDITIONAL ON WESTMORELAND, SOME ON SPACE COOPERATION.

PAGE 2 RUEHC 181918 UNCLAS

2. TUESDAY AFTERNOON PAPERS. WASHSTAR HORNER BONN REPORTS JOHNSON JOINED OTHER WESTERN LEADERS IN PAYING RESPECTS ADENAUER. CEREMONIES BROUGHT DE GAULLE JOHNSON TOGETHER FOR FIRST TIME SINCE KENNEDY FUNERAL. SHOOK HANDS BRIEFLY BEFORE ENTERING BUNDESTAG. WHEN PHOTOGRAPHERS URGED A HANDSHAKE, JOHNSON REACHED ACROSS LUEBKE AND CLASPED DE GAULLE'S HAND. LUEBKE STACKED HIS HAND ON THEIRS. JOHNSON LUEBKE SMILED AND FAINT TRACE OF SMILE REPORTED ON DE GAULLE'S FACE. ALSO PHOTO SESSION AFTER LUEBKE LUNCHEON. ORDERLY CROWDS ON CATHEDRAL ROUTE PRODUCED NO INCIDENT. AMERICAN OFFICIALS HOPE JOHNSON KIESINGER TALK WILL LEAD TO MEETING OF MINDS ON NPT. JOHNSON IS BEING TOLD GERMAN CONCERN FOR ITS FUTURE IN ATOMIC PEACEFUL USES HAS PASSED ITS CREST, AND HIS ASSURANCES TO GERMANY AND OTHERS MAY SHOVE ISSUE FURTHER INTO BACKGROUND. PROGRESS IS ALSO BEING MADE ON TROUBLESOME ISSUE OF OFFSET COSTS.

2A. WASHNEWS HAS BONN UPI REPORTING JOHNSON AND DE GAULLE EXCHANGED SERIES OF HANDSHAKES AND PLEASANTRIES THAT OPENED HOPES FOR LATER TALKS ON DETERIORATING FRENCH-AMERICAN RELATIONS. ALL EYES AT FUNERAL FOCUSSED ON THESE TWO. AFTER COOL START THEIR BRIEF EXCHANGES APPEARED TO HAVE BECOME MORE FRIENDLY.

UNCLASSIFIED

Orig filed in folder of TWXs to President

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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE
OS
FG11-4

EXECUTIVE SECRETARY

April 21, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Lunar Soft-Lander. The Nation's third Surveyor spacecraft, launched atop an Atlas-Centaur vehicle from Cape Kennedy on April 17, made a successful soft landing on the lunar Ocean of Storms area at 7:04 p. m. EST April 19. The landing took place on the side of a crater about 100 yards in diameter. The spacecraft is successfully transmitting high-quality TV pictures. The sampling, digging, and examination of the lunar surface are scheduled to be performed today. This is a major space success of a highly complex spacecraft.

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2. Other Launches

a. The ESSA V weather satellite was launched on an improved Delta vehicle April 20 from the Western Test Range. A polar orbit was attained successfully. The spacecraft contains two cameras for remote readout and a low-resolution infrared heat balance experiment.

b. The Department of Defense launched its third PRIME lifting body reentry spacecraft on an Atlas booster at Vandenberg AFB on April 19. It successfully traversed the 7000 mile range and was recovered in the programmed area.

c. A Department of Defense satellite was successfully launched on a Scout booster on April 12 from the Western Test Range.

3. Pending Launches

a. A Titan III-C carrying two Vela nuclear explosion detection satellites and three radiation measurement satellites is scheduled for launch April 25 at the Eastern Test Range.

b. The Italian San Marco satellite is scheduled for launch from a sea platform in the Indian Ocean near the coast of Kenya, Africa, on April 24. This is a cooperative U. S./Italian project in which the U. S. supplies the Scout booster and the Italians provide the spacecraft and perform the launch.

4. NASA Authorization. The Senate Space Committee began its hearings on the NASA FY 1968 Authorization on April 18. The Committee appears critical of the Apollo Applications and Voyager planetary projects for which substantial funds are being requested this year. Criticism has also been expressed of NASA's communications satellite research as being more appropriately the responsibility of private industry.

5. Apollo Accident

a. The Senate Space Committee has asked NASA to appear again by May 9, with revised Apollo program recommendations and schedule.

b. The House NASA Oversight Subcommittee is continuing its hearing on the Apollo accident in a one-day open session at Cape Kennedy on April 21.

6. Reliability. The Thor booster is beginning its second decade of reliable service and has flown successfully more than 200 times.

7. Soviet Communications. TASS announced an agreement to set up a satellite communications program "open to all countries willing to join." Delegates from Russia, Bulgaria, Hungary, East Germany, Cuba, Mongolia, Poland, Roumania, and Czechoslovakia met April 5-13 to discuss cooperation in space research and peaceful uses of outer space and to draft "a joint satellite and rocket launching program," as well as to create the orbiting communication system.

8. Manned Orbiting Laboratory Delay. The MOL new flight schedule calls for first flight in 1971 instead of the previously hoped-for 1969.

9. Soviet Activity. Reports emanating from Moscow cause anticipation of a space spectacular by the USSR very soon. It is predicted that new equipment will be used.

10. Space Payload Success Box Score
(April 21)

	U. S.		U. S. S. R.	
	1966	1967	1966	1967
Earth Orbit	23	21	14	18
Escape	0	2	2	0

Friday, April 21
Time: 10:45 a. m.

E. C. Welsh

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FOR PRESIDENT FROM GOLDBERG

BELIEVE YOU WILL BE PLEASED TO KNOW SENATE FOREIGN
RELATIONS COMMITTEE TODAY REPORTED OUT OUTER SPACE TREATY
BY AFFIRMATIVE VOTE OF 15-0.
KATZENBACH
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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

MW

EXECUTIVE SECRETARY

April 14, 1967

EXECUTIVE
OS
FG11-4

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

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1. Apollo Fire Investigation

The Apollo Accident Review Board's report was released April 9. It was blunt and critical of some aspects of the Apollo program.

The House Oversight Subcommittee heard witnesses from NASA, the Review Board, and the prime Apollo contractor on April 10-12. Five astronauts are also scheduled to appear before the subcommittee on April 17.

The Review Board and the NASA Administrator appeared before the Senate Aeronautical and Space Sciences Committee on April 11 and 13.

The Committees are probing managerial, technical, and operational shortcomings in the Apollo program, which may have had bearing on the tragedy.

Errors and unwarranted complacency have been admitted. Actions to offset mistakes are already under way.

2. Appropriations. NASA began testimony on its FY 1968 appropriations before the House Independent Offices Appropriations Subcommittee on April 12.

3. Launches. The Soviet Union on April 8 launched Cosmos 154 into a low, near-circular earth orbit. On April 12 it launched Cosmos 155 into a similar orbit from which the spacecraft is usually recovered after eight days.

4. Launch Failure. The third attempt by Japan to launch a satellite failed on April 12. The third stage of the solid-fueled 4-stage Lambda launch vehicle did not ignite properly.

5. Pending Launches

a. NASA's Surveyor III is scheduled for launch on April 17 for a soft landing on the moon on April 19. The spacecraft features a small

THE WHITE HOUSE
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1967 APR 14 AM 10 50

device which can claw some 20 inches into the lunar surface to explore its characteristics. A TV camera aboard the Surveyor will relay a view of the digging operation. The material is examined by a fluoroscope and spectrometer and the findings telemetered back to earth.

b. The Italian San Marco satellite is scheduled for launch on a NASA-supplied Scout vehicle from a towable platform in the Indian Ocean April 22.

6. Weather

a. ESSA III photographed three tropical storms in the Pacific area and satellite storm advisories were sent to appropriate authorities.

b. Public announcements from Saigon indicate that ESSA and Nimbus satellites are giving valuable assistance to U. S. bombing raids.

7. Lunar Landing Sites. NASA selected eight primary sites for Apollo landings along the equator in the flat lunar seas area. One of the sites chosen is the landing site of the Surveyor I. Selections were based on data received from that Surveyor and three Lunar Orbiters. The remaining two Orbiter spacecraft will be placed in near-polar moon orbit to observe other lunar areas of scientific interest.

8. French Space Plans. The French space agency, CNES, has given the go-ahead for the Super-Diamant launch vehicle development, at an estimated cost of $20 million. The booster is planned for orbiting the 240-pound D-2 satellite in 1969, which can be used for communications purposes.

10. Space Payload Success Box Score
(April 14)

	U. S. 1966	U. S. 1967	USSR 1966	USSR 1967
Earth Orbit	22	19	13	18
Escape	0	1	2	0

E. C. Welsh

Friday, April 14
Time: 10:15 a. m.

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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE SECRETARY

April 7, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Launches

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a. NASA launched an Applications Technology Satellite (ATS) from Cape Kennedy on April 5 on an Atlas-Agena launch vehicle. Due to failure of the Agena engines to re-start as programmed, the satellite remained in a highly elliptical instead of a 6,900 mile circular orbit. Even though the orbit is not as planned, the gravity gradient experiment is providing very useful data. All other experiments such as communications and meteorology are also operating successfully.

b. The Soviet Union launched Cosmos 153 on April 4 into an orbit from which the spacecraft is normally recovered after eight days.

c. Eighteen Japanese and U. S. meteorological rockets were launched in a 19-hour period April 5 at Wallops Island, Virginia. The series is designed for comparative studies of meteorological conditions at altitudes of 12 to 40 kilometers.

2. Pending Launches

a. Surveyor III is scheduled for launch April 17 on an Atlas Centaur from Cape Kennedy. This spacecraft, in addition to taking panoramic photos of the lunar surface after landing there, is to dig a 20-inch deep trench to provide more specific data about the surface composition.

b. A third Japanese attempt to launch a small satellite into earth orbit is still scheduled for the period ending April 13.

3. Congress

a. The Senate Commerce Committee's hearing on educational television will involve the following organizations beginning April 11: HEW, FCC, Virgin Islands Government, National Foundation on Arts and Humanities, Carnegie Commission on Educational Television, Ford

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1967 APR 7 AM 11 35

Foundation, National Educational Television, and National Association of Educational Broadcasters.

b. The House Science and Astronautics Committee's subcommittees are continuing their detailed review of the NASA authorization.

4. Scientist Astronauts. The National Academy of Sciences has recommended 69 scientist astronaut candidates from over 900 applicants for further screening by NASA, which expects to make its selection from the list by mid-August. There are now five scientists among the existing 47 astronauts.

5. Technology Utilization. The Small Business Administration's six-month trial program for utilization of NASA's spin-off technology has been so successful that it has formally agreed to extend the program through 1967. Thirty-seven percent of the companies affiliating with the NASA regional dissemination centers are small business firms which are willing to pay fees to have ready access to new areas of technology uncovered in the space program.

6. Weather

a. Weather satellites sighted Typhoon Violet in the Western Pacific April 2-4, and advisories were sent to the Philippines and Japan. Another tropical storm was sighted in the South Pacific March 28-April 4, and advisories were sent to Australia, New Zealand, and Fiji.

b. Three weather photos from an Applications Technology Satellite stationed in synchronous orbit 22,300 miles over the mid-Pacific are being transmitted daily to the World Meteorological Organization Congress meeting in Geneva, Switzerland, to demonstrate the availability of unique meteorological information.

7. Aircraft Noise. The Secretary of Transportation in testimony this week before the House Science and Astronautics Subcommittee on Research and Development reviewed the many facets of the Government program to reduce aircraft noise to tolerable levels. He said that the President's March 22 memorandum to Agency Heads on this subject has made it possible to insist that Federal funds will not be spent to create or further existing incompatible land use near airports.

8. **Space Payload Success Box Score**
(April 7)

	U. S. 1966	U. S. 1967	USSR 1966	USSR 1967
Earth Orbit	19	19	13	16
Escape	0	1	2	0

E. C. Welsh

Friday, April 7
Time: 10:40 a. m.

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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE
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FG 11-4

EXECUTIVE SECRETARY

March 31, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Launches

a. The Defense Department launched successfully a satellite March 20 from the Western Test Range. The launch vehicle was a Thor-Agena.

b. NASA launched two rockets last night (March 30) from Wallops Island, Virginia. The released chemicals caused colored clouds, thus making it possible to study air currents in the upper atmosphere. Contrary to anticipation, this display was not readily visible in Washington, D. C.

c. The Soviet Union launched two scientific satellites, Cosmos 151 and 152, into low altitude orbits on March 24 and 25, respectively. This makes ten Soviet launches within the last 30 days.

2. Pending Launches

a. The Applications Technology Satellite, ATS-A, is scheduled for launch April 4 from the Eastern Test Range aboard an Atlas-Agena vehicle. The 215-foot long, 815 pound satellite is scheduled to be placed into a medium altitude (6900 miles) circular orbit. The primary experiment of the satellite is to test gravity gradient stabilization.

b. A third Japanese attempt to launch a small satellite is scheduled between April 6 and 13 on the Lambda I launch vehicle from the Japanese SpaceCenter. NASA has agreed to provide world-wide tracking support for this operation.

3. Congress

a. The Apollo Review Board is expected to present its findings before the House's NASA Oversight Subcommittee in open hearings April 10. The Senate Committee probably will hold hearings soon on the same report.

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b. Hearings on the NASA authorization are scheduled to be resumed during the week of April 3 in the House Committee.

3. SST

a. Benefits. The supersonic plane may add \$20-\$50 billion to the GNP over a ten-year period according to studies made by the Air Transport Association. Development and long-term production of the 500 to 1200 such aircraft are expected to create an average of a quarter of a million jobs: 50,000 for prime contractors, 100,000 for subcontractors, and an additional 100,000 non-manufacturing jobs in supporting service and related industries.

b. Passenger preference. A recent airline poll of 200,000 air travelers showed that two-thirds would prefer the SST over other types of aircraft because of the speed of travel.

4. ComSat

a. The Atlantic Intelsat II satellite has been placed into a near perfect synchronous orbit on March 25. It is slowly drifting eastward to a longitude of 6° west. Acceptance tests will be completed in about ten days when it will be placed into commercial operation. ComSat Corp. has asked FCC for substantial reductions in rates.

b. Six common carriers and ComSat Corp. have signed a 50-50 ownership agreement for the three existing and three planned U. S. earth stations, thereby implementing the December 7, 1966 FCC decision directing this as an interim solution until 1969.

5. Air Traffic Control Experiment. A commercial jet successfully tested a new antenna. It was part of a satellite traffic control system between an aircraft over the Pacific, a satellite, and the control center in New York. Three other U. S. airlines and three foreign airlines have been encouraged by FAA to participate in similar tests with the satellite over the Pacific Ocean.

6. Spacecraft Sterilization. Industry estimates have placed the cost of sterilizing the Voyager planetary landing capsule and surface laboratory at 25 percent of overall program costs, or approximately \$500 million. In the meantime, there are experts who believe that U. S. planetary spacecraft sterilization requirements are excessive, particularly since there is some possibility that Soviet spacecraft have already contaminated the environment of Mars and Venus with viable earth-borne micro-organisms.

7. Air Force Fire. The Air Force team investigating the pure oxygen space chamber fire at Brooks Air Force Base, in which two airmen died earlier this year, has concluded that the most probable cuase was an electric arc from a break in insulated wire inside the chamber.

8. Iceland. The government of Iceland approved a planned expedition for astronauts and geologists in July 1967 to conduct astronaut training in the interior of Iceland. The conditions are considered to have similarities to the lunar environment.

9. U. S. - Japan Cooperation. The first two of a series of 10 pairs of Japanese and United States meteorological rockets are scheduled for launch at Wallops Island, Virginia, March 31. First to leave the launch pad will be a Japanese rocket to be followed fifteen minutes later by a U. S. rocket. The purpose of the Japanese-U. S. meteorological rocket project is to conduct comparative meteorological research at altitudes of 12 to 40 miles.

10. Distinguished Visitor. His Excellency Cevet Sumay, President of the Republic of Turkey, will visit the John F. Kennedy Space Center on April 5 for a general orientation and tour.

11. Space Payload Success Box Score
(March 31)

	U. S.		USSR	
	1966	1967	1966	1967
Earth Orbit	19	18	12	15
Escape	0	1	2	0

E. C. Welsh

Friday, March 31
Time: 11:00 a. m.

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WASHINGTON 20502

EXECUTIVE SECRETARY

(1)

March 24, 1967

EXECUTIVE
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MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Launches

a. An INTELSAT Communications Satellite was launched March 22 from Cape Kennedy into a highly elliptical orbit as planned. The launch was conducted by NASA for the Communications Satellite Corporation. The first move to position the satellite in a synchronous orbit will be made March 25.

b. The Soviet Union launched three spacecraft -- Cosmos 148, 149, and 150 -- on March 16, 21, and 22 respectively. This makes a total of eight launches in four weeks, and is a marked intensification of Soviet activity.

2. Congress

a. The Senate Commerce Committee will begin hearings April 11 on educational television and the use of communication satellites for this purpose. Witnesses from the Government, TV networks, various foundations, and the Communications Satellite Corporation are scheduled to appear.

b. The House Independent Offices Appropriations Subcommittee plans to initiate hearings on the NASA FY 1968 appropriation on April 10.

c. The subcommittees of the House Science and Astronautics Committee have been conducting hearings during the week of March 20 on the NASA authorization bill. The Apollo Fire is also being given subcommittee attention.

3. B-70. Management of the supersonic experimental B-70, initially developed as a possible strategic bomber for the Air Force, will be transferred to NASA March 25. Twenty-five flights have been scheduled for the next 15 months to study sonic boom, stability, control, and handling qualities of supersonic transports.

4. Tracking Facilities. The Prime Minister of Australia participated with NASA representatives in ceremonies opening the Apollo long-range tracking facility 25 miles southwest of Canberra. This station, with its 85-foot-diameter antenna, will operate with similar stations in Goldstone, California, and Madrid, Spain in the Apollo program.

5. Weather. The U. S. Coast and Geodetic ship Oceanographer has been equipped with an APT recording device to enable it to acquire pictures from weather satellites on its forthcoming around-the-world survey cruise. This will be especially useful for correlating surface measurements in remote areas of the South Pacific and Indian Oceans.

6. Apollo. The Apollo Applications Program is being defined beyond the first four flights to extend and evaluate man's ability to stay in space for periods beyond 56 days. Longer durations of a year or more will be scheduled on the basis of what was learned in the earlier flights.

7. Docking Equipment. Design and fabrication of the central element of the Multiple Docking Adapter for use in the Apollo Applications Program will be constructed in-house at NASA's Marshall Space Flight Center. It will be cylindrical, about 10 feet in diameter, and 11 feet long. Five vehicles will be able to dock simultaneously to the workshop through this adapter.

8. Space Payload Success Box Score
(March 24)

	U. S.		U. S. S. R.	
	1966	1967	1966	1967
Earth Orbit	15	17	11	13
Escape	0	1	1	0

E. C. Welsh

Friday, March 24
Time: 10:30 a. m.

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WASHINGTON 20502

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EXECUTIVE SECRETARY

March 17, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress

a. The Senate Aeronautics and Astronautics Committee has scheduled hearings on NASA's Authorization for FY 1968 on April 18 thru April 26. The committee plans to hear Department of Defense witnesses April 27 on the military aeronautcal and space projects.

b. Three subcommittees of the House Science and Astronautics Committee are presently conducting hearings on the NASA Authorization.

2. Launch. The Soviet Union launched Cosmos 147 March 14 into the type of low earth orbit from which similar spacecraft have been recovered after eight days.

3. European Space Research Organization

a. The ESRO satellite scheduled for launch by the U. S. March 15 from the Western Test Range was postponed because of higher priority use for the Scout booster and the facilities.

b. ESRO has contracted with NASA to purchase a Thor Delta launch vehicle and launching services for about $4 million. The vehicle will be used to place an ESRO satellite into a highly elliptical orbit (out to 120,000 miles from earth) to investigate the interplanetary magnetic field and study solar and cosmic rays. The satellite is scheduled for launch from Cape Kennedy in 1968.

4. OSO. The last of nine experiment packages was activated March 14 aboard the Orbiting Solar Observatory which was launched March 8. All of the experiments are functioning properly.

5. Weather Satellites

a. Launch of the U. S. Weather Satellite ESSA V is now scheduled for April 19 at the Western Test Range.

b. Data being received by the Soviet Union from the Cosmos 144 weather satellite have allowed it to double the number of weather charts furnished to the U. S. over the "cold line" last week. Although such information was furnished experimentally by the U. S. satellites in the past, operational gathering of such data by the U. S. is possibly two years away.

6. Moon Dust. 110 scientists from the United States and six other countries have been chosen by NASA to conduct experiments with the first samples of the moon's surface when they are returned to earth by U. S. astronauts. Scheduled are 122 such experiments with the approximately 50 pounds of lunar material anticipated.

7. INTELSAT. Launch of the Communication Satellite Corporation's INTELSAT II into synchronous orbit over the Atlantic for communication service between Europe and the U. S. is scheduled March 22 from Cape Kennedy.

8. Goddard Trophy. The Goddard Memorial Trophy was presented to Chairman George P. Miller of the House Science and Astronautics Committee by the President March 14, in the President's office.

9. Post-Apollo. NASA has unveiled its initial plans to use four Uprated Saturn I launch vehicles to orbit a mapping and survey system, an orbital workshop, a resupply mission, and the Apollo telescope mount. These initial Apollo Application payloads will be attached to the spent Saturn I second stage to form a "clustered" space station.

10. Space Payload Success Box Score
(March 17)

	U. S.		USSR	
	1966	1967	1966	1967
Earth Orbit	13	16	10	10
Escape	0	1	1	0

E. C. Welsh

Friday, March 17
Time: 10:30 a. m.

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MEMORANDUM

THE WHITE HOUSE

WASHINGTON

March 18, 1967
12:00 noon

MEMORANDUM FOR THE PRESIDENT

FROM: Mike Manatos

I saw Senator Mike Mansfield this morning and have just finished talking to Senator Morse in New Haven, Connecticut, with the following results:

(1) Wayne Morse will move consideration of the Summit Resolution at Monday's meeting of the Foreign Relations Committee. Mansfield will attend the meeting and "back Morse all the way."

(2) Morse has been assured by Carl Marcy that the Committee will dispose of the Space Treaty in 10 or 15 minutes. If there is undue delay in the Treaty consideration Morse will move to lay it aside and proceed with the Summit Resolution.

With reference to Investment Credit, George Smathers advises me he plans hearings Monday and Tuesday -- Executive Session Tuesday following the hearing -- reporting bill that day.

Mansfield will be ready to act on the Senate floor on Wednesday. Neither Mansfield nor Smathers anticipates any problem. However, should something unforeseen develop Mansfield would be prepared to continue the Investment Credit consideration when the Senate returns on March 29.

I will keep you posted on Guam as developments occur.

Rusk saw.
3/18/67
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EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE
OS
FG 11-4

EXECUTIVE SECRETARY

March 10, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Launches

a. NASA launched a third Orbiting Solar Observatory into a near circular orbit March 8 with a Thor Delta launch vehicle from Cape Kennedy. The 627 pound satellite is carrying nine scientific experiments and is performing satisfactorily. The first of this series of satellites was launched in 1962 and observed more than 140 solar flares; the second in 1965 transmitted 1,980 hours of scientific data.

b. The Defense Department successfully launched a second precision maneuverable reentry vehicle, using an Atlas launch vehicle, from the Western Test Range March 5. Though the reentry vehicle functioned properly and full telemetry data were obtained, the vehicle sank before it could be recovered.

c. The Soviet Union launched Cosmos 145 into an elliptical orbit March 3. Cosmos 146 was launched March 10.

2. Congress

a. The House Science and Astronautics Committee has completed its hearings of NASA witnesses on the FY 1968 authorization this week. Detailed subcommittee hearings are now under way.

b. The Senate Foreign Relations Committee opened its hearings on the Outer Space Treaty with the testimony of the Secretary of State and the U. S. Ambassador to the U. N. March 7. An executive session is scheduled for March 13.

3. Lunar Orbiter. Lunar Orbiter III successfully transmitted to earth 182 out of the 211 (86%) photographic frames taken of the lunar surface. Technical difficulties prevented receipt of the rest of the pictures. Full coverage was obtained on six of the 12 primary Apollo landing sites and partial coverage was obtained of the other six sites.

4. Pending Launch. The European Space Research Organization (ESRO) is scheduled to have its first satellite launched into orbit on March 15 by

NASA from the Western Test Range using a Scout booster purchased from the U. S. The satellite will conduct solar astronomy and cosmic ray studies.

5. French Test. A French rocket launched a probe to an altitude of 150 miles March 7. This capsule, containing a monkey, was launched to test primate behavior during weightlessness.

6. Soviet Display. The Soviets are reported as intending to exhibit at the Paris Air Show this coming May the Vostok I launch vehicle which launched Cosmonaut Gagarin into space in April 1961.

7. Weather Satellites

a. U. S. weather satellite Essa V will be launched in mid-April from the Western Test Range. It will carry two wide area cameras and infrared sensors and will be in a polar orbit so that each pass will be at 3:00 p. m. local time. Essa IV makes a similar pass at 9:00 a. m. local time.

b. The Soviets are transmitting to the U. S. over the "cold line" between 20 and 30 cloud analysis charts per day together with three to five photo facsimiles of interesting weather phenomena. In addition, temperature analysis of cloud tops in selected areas and data on the total outgoing radiation from the earth are being supplied. This information is being obtained from Cosmos 144.

8. Fragment. A fragment found near Monterey, Mexico on February 12. has been identified by a NASA technical expert as coming from a U. S. space vehicle. Embassy Mexico is being requested to arrange for return of the fragment to the United States.

9. Space Payload Success Box Score (March 10)

	U. S. 1966	U. S. 1967	USSR 1966	USSR 1967
Earth Orbit	11	16	9	9
Escape	0	1	1	0

E. C. Welsh

Friday, March 10
Time: 10:30 a. m.

EXECUTIVE
OS
FG 11-4

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE SECRETARY

March 3, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Launches

a. The Department of Defense launched from the Western Test Range a classified satellite into near polar orbit February 24 using a Titan IIIB launch vehicle.

b. The Soviet Union launched Cosmos 143 February 27th into a low earth orbit from which the spacecraft is normally recovered after eight days.

c. NASA propelled a small iron pellet into the atmosphere at a speed of more than 38,000 miles an hour February 27 using a Trailblazer II rocket launched from Wallops Island, Virginia. The experiment resulted in the creation of an artificial meteor of great velocity and was conducted to increase knowledge of the mass, density, and composition of natural meteoroids.

d. The Soviet Union launched a new weather satellite, Cosmos 144, February 28 into a 384 mile orbit inclined 81 degrees from the Equator. Shortly after the orbit the Soviet Union resumed transmitting cloud analysis data to the United States over the "cold line."

2. Congress

a. The House Science and Astronautics Committee plans to complete its hearing of NASA witnesses during the week of March 6, after which the three subcommittees will review details of the NASA program.

b. The Senate Aeronautical and Space Sciences Committee received an updating report on the Apollo fire on February 27.

c. The Joint Atomic Energy Committee heard from AEC-NASA witnesses on the nuclear rocket program on February 28.

d. The Senate Aeronautical and Space Sciences Committee completed its hearing of witnesses on aeronautics research on February 27 with testimony from Defense and the National Aeronautics and Space Council.

3. Automatic Landing. A commercial jet aircraft fully loaded with passengers was landed at Kennedy Airport February 27 by an automatic instrument radio beam. This is the first time that an automated landing has been executed using a regularly scheduled commercial airliner.

4. Apollo Modifications. NASA has announced that the "hatch" of the Apollo spacecraft will be modified and that some materials will be replaced with less flammable materials. All materials which had been designed for the Apollo had been selected and previously tested for ignition below 400 degrees and in a 100 percent oxygen atmosphere at five pounds of pressure per square inch. The exact cause of the fire is still undetermined. The Review Board investigating the accident expects to conclude its inquiry and file a final report in about a month.

5. Saturn V. The second and third stages of the giant Saturn V have been locked into place at Cape Kennedy. The complete vehicle should be moved to the launch area by late March and ready for launch in June or July.

6. Communications Diplomacy. A March 5 discussion between the U. S. Secretary of State and the Japanese Foreign Minister is scheduled to be relayed to the United States via an Intelsat communications satellite and broadcast throughout the United States.

7. Launch. A new test vehicle for precision reentry from space will be launched from the Western Test Range on an Atlas booster March 4. The spacecraft is programmed to perform a series of maneuvers prior to landing at a predetermined recovery point.

8. Solar Physics. Two Orbiting Solar Observatories are scheduled for launch by NASA to study the sun and its influence on the earth's atmosphere. Each of these spacecraft will carry nine experiments. The first Observatory is expected to be launched March 8 from Cape Kennedy, and the second will follow 60 to 90 days later.

9. ESRO Satellite. The European Space Research Organization has announced the planned U. S. launch of that organization's satellite at the Western Test Range, March 15. The satellite is designed to carry out experiments in solar astronomy and measurement of cosmic rays.

10. Lunar Orbiter. After transmitting 70% of the pictures it took of the moon's surface, the spacecraft ceased operation.

11. Space Payload Success Box Score
(March 3)

	U. S. 1966	U. S. 1967	U. S. S. R. 1966	U. S. S. R. 1967
Earth Orbit	10	15	9	7
Escape	0	1	1	0

E. C. Welsh

Friday, March 3
Time: 11:00 a. m.

MEMORANDUM

THE WHITE HOUSE

WASHINGTON

EXECUTIVE

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March 2, 1967

MEMORANDUM FOR YOICHI OKAMOTO

FROM: George Christian

NBC News is preparing a television feature on NASA and the space program. They would like any photographic coverage we have of the President's Science Advisory Committee which last met on March 21, 1966. The photographs are needed as soon as possible.

Central Files:

Donald Hornig has been informed that no motion pictures were taken on this subject and has relayed the message to NBC.

Okamoto
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EXECUTIVE OFFICE OF THE PRESIDENT
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EXECUTIVE SECRETARY

rec'd 2/24/67 1:45p

February 24, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Congress

a. The Senate Aeronautical and Space Sciences Committee has scheduled an open hearing February 27 on the Apollo capsule fire. The hearing is expected to cover the interim findings of the Review Board and any decisions that may have been made by NASA affecting the Apollo program.

b. The appearances of the Secretary of State and the U. S. Ambassador to the United Nations before the Senate Foreign Relations Committee on the Space Treaty have been postponed until March 7.

c. Review of NASA's Authorization by the Senate Aeronautical and Space Sciences Committee is scheduled to begin April 10. The House Committee hearings begin February 28.

2. Launch. The Department of Defense launched a classified military satellite into near polar orbit from the Western Test Range February 22 with a Thor launch vehicle.

3. Lunar Orbiter III. The U. S.'s third picture-taking satellite in lunar orbit has now completed taking 422 out of 424 programmed photographs of the lunar surface covering all primary landing sites for the manned Apollo landing. The spacecraft will continue to transmit photographs back to earth during the next ten days. Photographs received have been excellent.

4. Biosatellite. NASA terminated the search for BIOS I four days after it had reentered the earth's atmosphere in or near Australia.

5. Japanese Attempt. Japan will make a third attempt to orbit a satellite April 6. Two previous orbiting efforts have failed.

6. French ComSat. France has announced plans to build a larger and more powerful telecommunications satellite than the present U. S. Intelsat II. Designated Saros, the spacecraft would provide direct telephone, radio,

THE WHITE HOUSE
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1967 FEB 24 AM 10 58

and television links between France and French-speaking African countries. French plans are to launch the synchronous spacecraft in 1970 from their new launch range in French Guiana using the European Launcher Development Organization's (ELDO) Europa rocket.

7. Weather Satellites. U. S. weather satellites sighted a tropical vortex in the South Indian Ocean February 15 and tracked a tropical storm in the western South Pacific February 19-20. Threatened areas were warned.

8. Award. House Space Committee Chairman George Miller will be the recipient of the annual Robert H. Goddard Memorial Trophy presented annually by the National Space Club.

9. Space Tracking. NASA's Deep Space Network is responsible for two-way communications with unmanned spacecraft traveling from approximately 10,000 miles from earth out to interplanetary distances. Present facilities permit simultaneous control of a newly launched spacecraft and a second one already in flight. The capability is being improved for simultaneous control of either two newly launched spacecraft plus two in flight, or four spacecraft in flight.

10. Soviet Space Plans. Responsible Soviet officials have responded in the negative to questions as to whether the USSR plans any special space achievement for the fiftieth anniversary of the Socialist Revolution. Whether or not such plans are being made, it is evident that the Soviets do not want to announce them ahead of time.

11. Nuclear Test. A full power (1500 megawatts) test was successful February 23 at Jackass Flats, Nevada. It ran at design temperature at this full power for 30 minutes.

12. Space Payload Success Box Score
(February 24)

	U. S. 1966	U. S. 1967	U.S.S.R. 1966	U.S.S.R. 1967
Earth Orbit	9	14	8	5
Escape	0	1	1	0

E. C. Welsh

Friday, February 24
Time: 10:30 a. m.

EXECUTIVE

(8)

IV1/1967/FG216
FG11-9
OS
PR8-1

Goddard, Robert H.
Welsh, Edward C.
Barthold, Gregory B.

FOUNDED OCTOBER FOURTH, 1957 AS THE NATIONAL ROCKET CLUB

NATIONAL SPACE CLUB

1625 EYE STREET, N.W., WASHINGTON, D. C. 20006
PHONE 296-4690

February 17, 1967

Mr. James R. Jones
Assistant to the President
The White House
Washington, D. C.

Dear Mr. Jones:

With reference to my letter of February 10, 1967, please add the names of Mr. James E. Webb, Administrator, National Aeronautics and Space Administration and Mrs. George P. Miller, to the list of attendees for the presentation of the Dr. Robert H. Goddard Memorial Trophy on 15 March.

Sincerely yours,

NATIONAL SPACE CLUB

Bob Hood

Robert H. Hood, Jr.
President

Date of Appointment WED. - MAR. 15 - 1967 11:30

Notification relayed to Hood

by Jim Jones on 2-10-67

who said appointment was __✓__ a) off record, no publicity unless announced by White House, enter S.W. Gate; ____ b) on record.

Copies Sent to Mrs Territo

/6

EXECUTIVE

OS

FO 11-4

EXECUTIVE OFFICE OF THE PRESIDENT
NATIONAL AERONAUTICS AND SPACE COUNCIL
WASHINGTON 20502

EXECUTIVE SECRETARY

February 17, 1967

MEMORANDUM FOR THE PRESIDENT

Subject: Space Activities

1. Launches

a. The Soviet Union launched Cosmos 142 into a low elliptical earth orbit February 14.

b. France's fifth satellite was launched into orbit from its Algerian launch range February 14. This was the second geodetic satellite in two weeks to be launched by France, and the last satellite to be launched from this base. Future French launches will be made from French Guiana.

2. Congress

a. Testimony on the Space Treaty begins before the Senate Foreign Relations Committee on February 24.

b. The Senate Aeronautical and Space Sciences Committee will conclude its hearings on aeronautics February 27.

c. The House Science and Astronautics Committee plans to hold six days of hearings on the NASA Authorization beginning February 28. After these hearings, the Committee's various subcommittees will begin detailed considerations of the NASA program.

3. Biosatellite. The U. S.'s Biosatellite, which was scheduled to return to earth shortly after its launch December 14, finally reentered the atmosphere after its 999th orbit. An aircraft search for the 280-pound satellite is being conducted in the Australian interior.

4. Lunar Orbiter 3. The U. S.'s newest lunar-photographing satellite is now orbiting the moon every three hours and 28 minutes, and its photographs of the lunar surface are excellent. Its pictures are expected to add detailed knowledge of twelve proposed landing sites for the manned Apollo lunar landing vehicle.

5. Communications Satellites. Launch of the Communication Satellite Corporation's newest INTELSAT II satellite, which is scheduled to be

THE WHITE HOUSE
RECEIVED

1967 FEB 17 PM 12 09

positioned over the Atlantic, has been delayed from February 15 to mid-March to permit re-checkout of the launch vehicle's solid top stage.

6. Weather Satellites. NASA has turned operational control of weather satellite ESSA IV, launched January 26, over to the Department of Commerce. The satellite is operating successfully and its pictures are available for pick-up at 180 ground stations throughout the world.

7. Apollo Accident. The investigation into the tragic Apollo accident is continuing, with hope that additional findings will be available next week. Cause of the fire is still unknown, although its progress throughout the capsule has been traced. The astronauts' suits were burned somewhat, but the cause of death was asphyxiation.

8. Nuclear Rocket Test. Ground testing of an increased power (1500 megawatts) Phoebus-IB nuclear rocket reactor is scheduled at the Nevada test site February 17.

9. Conference Postponement. The Outer Space Committee of the United Nations has agreed to a Soviet request to the General Assembly that the scheduled UN Conference on Exploration and Peaceful Uses of Outer Space be postponed until next year. The Conference was to have been held September 11-23 in Vienna.

10. TV Weather Mosaic. The National Environmental Satellite Center began daily distribution to news services February 15 of a satellite photo mosaic showing the weather pattern over the North American Continent. The mosaic is expected to be utilized by TV weather programs.

11. Jet Noise Study. NASA plans to negotiate contracts totaling over $10 million with two major aerospace companies for research to achieve significant reductions in the noise generated by commercial jet transports.

12. Space Payload Success Box Score
(February 17)

	U. S. 1966	U. S. 1967	U. S. S. R. 1966	U. S. S. R. 1967
Earth Orbit	9	13	6	5
Escape	0	1	1	0

E. C. Welsh

Friday, February 17
Time: 11:00 a. m.

JMT/ PRESIDENTIAL MESSAGE 15 1967

EXECUTIVE
PR9/CO81 (4)
CO 81
OA
OS
FG155

Filed 2/17/67

Welcome to the United States Pavilion.

I extend to the people of France and to visitors from nations around the world the greetings and good wishes of the American people.

Our country's exhibition at this 27th X International Aviation and Space Salon is a mutual endeavor of American private enterprise and the United States Government. It reflects the shared hope of our government and industry for international cooperation on this planet and in the exploration of outer space.

We believe that the Paris Air Show, by stimulating the exchange of technology, products, and services, advances the fulfillment of this hope. The worldwide diffusion of knowledge and products enables each country to build upon the achievements of other countries for the greater good of all.

The United States welcomes the opportunity to join with all nations in contributing to our common cause of world peace and progress.

LBJ/Commerce/WSparks/WShoemaker/gbk
cc: Juanita Roberts/Bob Fleming/Whitney Shoemaker/ sent
Mary Hooper/Central Files

(Message for Paris Air Show, Mary 26-June 4, 1967)
Requested by Department of Commerce

Notify Henry Scharer when signed)
(112-3142)

lb

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FEB 17 1967
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LEGISLATIVE REFERENCE SERVICE

Filed 2-15-67

RECORD OF THE VICE PRESIDENT ON SPACE ACTIVITIES

DURING 1957 - 1962

By

Eilene Galloway
Specialist in National Defense
Foreign Affairs Division
March 9, 1962

Filed by Mrs. Territo
Used in connection with the Space Treaty

RECORD OF THE VICE PRESIDENT ON SPACE ACTIVITIES DURING 1957 - 1962.

1. Chairman, Senate Preparedness Investigating Subcommittee of the Senate Armed Services Committee.

On November 25, 1957, the month following the orbiting of the first earth satellite by the Soviet Union on October 4, 1957, Senator Lyndon B. Johnson took the initiative in beginning the first Congressional hearings on the status of the United States satellite program. The Inquiry into Satellite and Missile Programs resulted in testimony from the nation's experts during the following two months, and on January 23, 1958, the Subcommittee unanimously concluded that decisive action must be taken in 17 areas to strengthen United States defense and accelerate our space program. For example, the Subcommittee urgently recommended that work be started at once on developing a rocket motor with a million pounds thrust. The hearings were resumed on February 26, 1958 to determine what progress had been made in speeding up United States programs. Continuing on April 3 and July 24, 1958, this Congressional investigation resulted in a total of 2476 pages of basic information and analysis required for decision-making and executive action.

2. Chairman, Senate Special Committee on Space and Astronautics.

Established on February 6, 1958, the Special Committee studied the use of resources, personnel, equipment, and facilities required for the United States to achieve a preeminent position in outer space. This committee was responsible for the Senate hearings which resulted in the passage of the National Aeronautics and Space Act of 1958. Among the committee's accomplishments was recognition of the necessity for a comprehensive space program, civilian and military, in order to avoid duplication and ensure economy and efficiency. This committee was the first governmental body to recognize that in addition to NASA and the Department of Defense, there are other executive agencies with space activities which need to be coordinated. Thus it was the Senate Special Committee which identified the problem of interdepartmental coordination and laid the ground work for the National Aeronautics and Space Council. The Chairman also initiated the first study of Space Law, resulting in the publication in December 1958 of a symposium on the legal problems likely to arise from the exploration and use of outer space.

3. Chairman, Senate Committee on Aeronautical and Space Sciences.

This new standing committee, established on July 24, 1958, was responsible for authorizing the annual appropriations of NASA and in this connection made a thorough investigation of NASA's policies, programs, and the budget. Recognizing the significance of space communications, the Chairman initiated staff studies which resulted in the publication of Radio Frequency Control in Space Telecommunications (March 19, 1960), and Policy Planning for Space Telecommunications (December 4, 1960). Continuing his interest in national and international legal problems, the Chairman directed that a study be made of the Legal Problems of Space Exploration, resulting in a document which was published on March 22, 1961 after the Chairman became Vice President of the United States.

4. Represented the United States at the United Nations.

On behalf of President Eisenhower, Secretary of State Dulles invited Senator Lyndon B. Johnson, Majority Leader of the Senate, to address United Nations Committee No. 1 (Political and Security) in support of the resolution to establish the United Nations Ad hoc Committee on the Peaceful

Uses of Outer Space. On November 17, 1958, Senator Johnson expressed the unity of the executive and legislative branches of the Government, as well as bipartisan support for United States policy that space activities should be devoted to peaceful purposes for the benefit of all mankind. Urging international cooperation, Senator Johnson declared that outer space is "free, unscarred by conflict, and must remain that way."

5. Chairman, National Aeronautics and Space Council.

By amendment of the NASA Act on April 25, 1961, the Vice President became Chairman of the Space Council whose function is "to advise and assist the President, as he may request, with respect to the performance of functions in the aeronautics and space field..." Among the major activities of the Vice President thus far in discharging his responsibilities has been advice and assistance in

(1) Selecting the first professional staff of the Space Council.

(2) Developing United States national space goals and supporting budgetary requirements.

(3) Speeding up the big booster program.

(4) Developing the national communications satellite policy ~~and draft legislation~~.

(5) Improving coordination of space activities by various Government agencies in general and on such matters as uniformity of patent policy and approval of the first launching of a nuclear power source for a space shot.

(6) Formulating United States policy on international space cooperation in the United Nations.

(7) Initiating studies on the sovereignty limits of air space and aerospace medicine.

(8) Coordinating the President's 1961 Report to the Congress on Aeronautics and Space Activities.

6. Speeches on the Exploration and Use of Outer Space from October 18, 1957 to the present time, 1962.

An evaluation of approximately 40 speeches reveals that the Vice President has a consistent and continuing record of informing the people concerning the significant factors of national and international space activities. The main points that have been stressed are:

(1) United States national security, and that of the free world, depends upon our achieving preeminence in space.

(2) The techniques used to launch satellites are the same as those which can be used to fire intercontinental ballistic missiles. The Soviet Union has demonstrated its capability in rocketry and we are in a space race with the Russians.

(3) The United States must establish a firm lead in science and technology. We have the brainpower and resources to do the job.

(4) Defense is far more than a military response, and the establishment of leadership requires improvement in education at all levels from grade school through college.

(5) Economic returns from the United States space program will result in tremendous benefits to the economy.

(6) The importance of international space activities was recognized as a factor in preserving world peace. Imaginative leadership by the United States in sharing the peaceful uses of outer space was emphasized.

(7) Suggestions were made to strengthen the United Nations in its work on the peaceful uses of outer space.

(8) In speaking before the United Nations at the invitation of the Eisenhower Administration, the Majority Leader of the Senate became a symbol of bipartisan foreign policy, stressing the fact that on the policy of using space for peaceful purposes there are no differences between political parties and that the Executive and Legislative Branches of the Government are unified.

BEAUMONT ENTERPRISE
November 19, 1958

Mr. Johnson at the U. N.

SENATE Majority Leader Lyndon Johnson's appearance before the United Nations was representative of bipartisanship on foreign policy at its best.

The Texan told the peace organization that both the Democratic and Republican Parties solidly support President Eisenhower's proposal for international co-operation in control of outer space.

We can't conceive of doubt in the mind of anybody as to just how Democratic Party leadership would stand on this vital issue. Still, the senator's outspoken statement on the subject undoubtedly strengthens the American position in the eyes of the rest of the world.

The Eisenhower administration was, of course, being practical when Secretary of State Dulles invited Mr. Johnson to appear before the 81-nation political committee and underline U. S. solidarity.

Actually, many people were surprised to learn that it was the first time a leader of the political opposition had addressed the U. N., although the U. S. delegation includes both Republicans and Democrats.

It is inevitable, we suppose, that during every election campaign and during every session of Congress there will be some debate on certain aspects of the nation's foreign policy. Basically, this is healthy, although we must never allow these discussions to become divisive beyond a point. There must always be a closing of ranks somewhere.

Regardless of the differences in opinion that always exist, strong efforts should be made at all times to find grounds for complete agreement in the field of foreign policy and to emphasize these accords in the eyes of other nations.

In the invitation to the senator to appear at the U. N. and in his acceptance, Mr. Dulles and Mr. Johnson have performed a splendid service to their country and to the cause of peace.

This is a highlight of the Senate majority leader's statement:

"On the goal of dedicating outer space to peaceful purposes for the benefit of all mankind, there are no differences within our government, between our parties, or among our people. The executive and legislative branches of our government are together. United we stand."

This is good talk, indeed.

KAUFMAN HERALD
November 13, 1958

Johnson Is Key Figure

Senate Democratic Leader Lyndon B. Johnson of Texas emerged from the November 4th general election, which gave the United States Senate a record Democratic majority, as the key figure who will help shape the political destiny of the 86th Congress.

Senator Johnson was consistently advocated "constructive, responsible, moderate" Democratic action.

On the other hand, he has shown he can interpret that philosophy to include make-work spending as well as mid-ground compromising on such issues as civil rights.

Political observers think Johnson may have more trouble keeping party harmony in a Senate which has 62 Democrats instead of 49, but he is reported ready to come up with a strong program of legislative action ecovering most of the points demanded by his liberal Democratic colleagues.

Because of the division among Democrats over civil rights, Senator Johnson's chances of getting the Democratic presidential nomination in 1960—assuming he might want it—are said to be tied to his appeal as a "Compromise" candidate, plus his record in Congress as a "can do" leader.

The presidential aspirations of others are expected to come a lot closer to the surface in the Senate and in various state capitals in the next two years.

High on the list are Democratic Sens. John F. Kennedy of Massachusetts and Stuart Symington of Missouri, both of whom won smashing victories on Tuesday. It includes Democratic Sens. Hubert H. Humphrey of Minnesota, and Albert Gore and Estes Kefauver, both of Tennessee. Democratic Sen.-elect Edmund S. Muskie of Maine, a newcomer, also must be counted as a potential candidate for the future.

California's governor-elect, Democrat Edmund G. Brown, brings a new prospect into the presidential area. Brown, like Michigan's Gov. G. Mennen Williams, who won his sixth term this week, may find his political horoscope altered by what Johnson and House Speaker Sam Rayburn get through the new Congress.

New Jersey's Gov. Robert G. Meyner, a strong presidential possibility in a state which grabbed a Senate seat from the GOP, is another in the same boat.

WICHITA FALLS TIMES
November 18, 1958

Missions Give Words Meaning

Not one but two diplomatic assignments have been accepted by Majority Leader Lyndon B. Johnson, the senior Senator from Texas, and for both he is particularly well-fitted.

His appearance before the United Nations to speak in support of the United States resolution for the peaceful uses of outer space was no doubt prompted by his early interest in the subject. Last January, Senator Johnson first saw the possibilities of an outer space agency within the United Nations as a means of coordinating the exploration of space beyond earth and of preventing the jurisdictional disputes which have marked man's exploration of his own globe. At that time, the proposal went unheeded by the Eisenhower Administration. The validity of the idea has now borne fruit, however, even if it did take a sweeping Democratic victory in the general election to introduce a bipartisanship note into the presentation before the United Nations.

For the second assignment, Senator Johnson has agreed to go to Mexico on a special good will mission to discuss with President-elect Adolfo Lopez Mateos ways of improving relations between the two nations. Texas, the state he so ably represents in the Senate, has a lengthy common boundary with Mexico, and as a resident of Central Texas, not too far removed from it, Senator Johnson has a personal knowledge of the major difficulties which are involved.

In both the offers and the acceptances can there be detected action which puts meaning into words uttered by President Eisenhower, Senator Johnson and other Democratic leaders after the GOP lost so much ground in the general election. These spokesmen for the two parties indicated a desire to get along with each other for the best interests of the nation, and Senator Johnson's assignments are an indication that a good beginning has been made.

MARSHALL NEWS MESSENGER
November 18, 1958

Johnson's Selling Role

The United States is in a battle for world trade markets and is losing some ground in Latin America. Sen. Lyndon Johnson who was in Marshall over the weekend for the Patman program, took notice of this condition in a speech at Victoria.

When this nation permits the inflation spiral to continue as it has in recent months, it puts industry at a continuing disadvantage. This helps to put prices out of range of our neighbors in the Western Hemisphere. The advantage of proximity is thus diluted.

Mr. Johnson's being named by the administration to discuss continental problems with President-elect Adolfo Lopez Mateos of Mexico should lead to a helpful advance on the trade front. Moreover as tactical leader of the Democrats in the Senate, he is in a position to push to a proper conclusion some of the understanding he has about the situation.

EL PASO TIMES
November 25, 1958

The Right Track

The Acapulco meeting between U. S. Senate Majority Leader Lyndon Johnson and Mexico's President-elect Adolfo Lopez Mateos may have laid the framework for a number of discussions between Washington and Mexico.

The two leaders agreed Sunday, according to The Associated Press, that barriers between the two countries should and could be lowered.

Although the exact barriers were not specified, Sen. Johnson said after the talk that their removal "would set before the world the example of trusting neighbors."

It is no secret that metals and cotton are touchy subjects.

When asked whether the metal quota problem had been discussed, Sen. Johnson replied:

"This was not a commodity conference."

In meeting President-elect Lopez Mateos, Sen. Johnson naturally had the approval and the blessing of our State Department.

As a strong exponent of one foreign policy, we may be certain that Sen. Johnson outlined carefully with the State Department what would be discussed in Acapulco.

There are a number of matters which could be handled in such a manner that would improve relations across the Rio Grande. Our Good Neighbor Policy of a few years ago needs some working over. It should never be taken for granted.

WACO NEWS - TRIBUNE
November 19, 1958

Johnson Sets Example Of Rising Above Partisanship

All Texans can take pride in the fact that U. S. Senator Lyndon B. Johnson has been given two major diplomatic assignments by the President of the United States, and has undertaken them without delay even though they came at the time when his duties as Senate Majority Leader are piling up toward the next session of Congress.

Senator Johnson's mission to the United Nations could turn out to be the biggest, most important task he ever has tackled. Certainly, no more capable and influential American could have been chosen to represent this nation as a speaker on behalf of the American resolution before the UN for the peaceful use of outer space as men begin to penetrate that unknown dimension.

And Lyndon Johnson's contribution, by presidential assignment, to the improvement of relations between the United States and Mexico likewise transcends partisan considerations. The new president of Mexico, Alfredo Lopez Mateos, and the Senator from Texas will be making history when they sit down together to compare ideas and find common ground for the benefit of both nations.

In accepting from President Eisenhower these two commissions, Senator Johnson is performing as a model for the Democrats who follow his leadership. There were harsh words exchanged by Mr. Eisenhower and Senator Johnson in the heat of the fall election campaign. They speak, do these two men, for opposing political parties. Yet with the battle over, and Johnson's forces the winner by a landslide, the Texan is going out of his way to demonstrate that partisanship stops at the international boundary, and at the limit of man's pull against gravity.

Every year Lyndon Johnson grows in stature and in usefulness to the world. He has his critics, he has his bitter political opponents. None of them can take away the image of a hard-driving, determined, dedicated, imaginative American intent only on serving his fellow-citizens. Texas gave him to the world and it was no small gift.

HOUSTON POST
November 18, 1958

Johnson Speaks for Space Control

Sen Lyndon B. Johnson's speech before the United Nations Political Committee Monday was an impressive demonstration of the ability of the American people to lay aside political differences in matters of great concern to the future well-being of the nation or the world.

To some of the delegates the spectacle of the leader of the opposition giving his full endorsement to a proposal by the President probably was a new experience, but Johnson, Senate Democratic leader, was voicing the national feeling when he said all Americans are behind the President's proposal for international co-operation in outer space to the end that it be used only for peaceful purposes.

Johnson's purpose in participating in the UN debate on outer space was to dispel any doubts as to whether the government still commands the full support of the country on this issue, in view of the Democratic victory at the recent general election. He very likely succeeded in doing so. Specifically, Johnson endorsed a resolution submitted to the committee last week by the United States and 19 other nations proposing the creation of a special UN group to lay the groundwork for an international space agency.

He said the people of the U. S. "do not acknowledge that there are landlords of outer space who can presume to bargain with the nations of the earth on the price of access to this new domain."

Johnson's action meant that the nations of the world now have strongest kind of assurance that a space agency established under the UN would receive congressional approval. The path toward adoption of the resolution has been made easier.

NEW YORK MIRROR
November 19, 1958

United We Stand

Senator Lyndon Johnson, Democratic leader in the Senate and currently a delegate at President Eisenhower's request to the General Assembly of the United Nations, told the representatives of 80 nations, in effect, "there are no differences within our government, between our parties, or among our people" in facing major international problems.

To most Americans this is a truism. We take it for granted. To many foreigners, it will appear to be unbelievable. They cannot understand our curious system of parties and elections in which personal antagonisms and hatreds play practically no part.

They think in terms of revolutions, coups d'etat and similar devices to change governments.

They find it difficult to understand that a campaign such as Messrs. Harriman and Rockefeller conducted is "politics," and that should they be called upon, these men will work together in the interest of the country or the state no matter what they said during a campaign.

It was good to have a Democratic leader such as Lyndon Johnson tell this to the Europeans, Africans and Asians at this time when some of them will make the mistake of believing that because so many Democrats were elected during the last election, the country is not supporting President Eisenhower and Secretary of State John Foster Dulles in their foreign policy.

The Russians cannot take advantage of that situation —not in our country.

True, Senator Lyndon Johnson was discussing the relationship of the United States to outer space, but it would not matter if the subject referred to Hungary or Poland or Red China or whatever it may be.

Nor will President Eisenhower or Secretary of State Dulles resign because they lost an election. We do not do it that way.

While we are a free people and may have many differences of opinion, we are also a united people in our love of country and in our unanimous decision that our nation will neither tolerate humiliation nor indignity.

On that we stand united—absolutely and irrevocably united.

CHRISTIAN SCIENCE MONITOR 11/20/58

Send to Geo. Reedy in Japan

Space Control Inches Closer

Just as outer space itself seems, and is, very far away, so the international control of it for peaceful purposes has seemed very remote. But a change of position by the Soviet Union, announced by Deputy Foreign Minister Zorin, may enable the Political Committee of the United Nations General Assembly to bring it a little closer.

Mr. Zorin at first demanded that space control be hinged upon American withdrawal from foreign military bases, a large and complex question in itself. The United States a year ago made what seemed to it the major concession of being willing to discuss space control alone and not as part of the general problem of arms reduction.

There came then a notable speech by Senator Lyndon Johnson which stressed that on space control the Democratic majority of the Senate stood fully behind the Eisenhower Republican administration. It would be easy to infer that Moscow was impressed by this unity, but Soviet diplomacy probably does not work that fast.

More likely, the Soviet Foreign Office recognized the far-fetched character of its reasoning and was content to put in a propaganda shot at the bases and get credit for withdrawing an objection. The Johnson speech had ample significance in American internal politics.

What remains now is to agree on the composition of a preparatory commission to study what kind of space agency should be set up and what its function should be. There is ample area for disagreement in this.

One source of friction is removed by excluding intercontinental military missiles from consideration. A few laymen may ask, "What else is there to be concerned about?" Well, there is, for example, the matter of preventing eventual use of space platforms from which to direct a rain of destruction on targets below.

THE CHRISTIAN SCIENCE MONITOR
November 17, 1958

Johnson Props U.S. Space Stand

By William R. Frye
United Nations Correspondent of The Christian Science Monitor

United Nations, N.Y.

Senator Lyndon B. Johnson (D) of Texas has given the Eisenhower administration a welcome and possibly even decisive boost in a difficult United Nations predicament.

He has done so by proclaiming that the United States Congress and people are united behind the objective of "full and complete and immediate cooperation to make the exploration of outer space a joint adventure."

The incident may have at least as important domestic implications as it has international; it may help smooth the course of executive-legislative relations during the next two years; it may still further enhance the already towering position Senator Johnson holds on Capitol Hill; it might even help boost him toward a Democratic presidential nomination in 1960.

UN Diplomats Watch

But UN diplomats and observers are more immediately concerned with the effect of the senator's intervention in the current debate on outer space in the Political Committee of the 81-nation UN General Assembly.

The United States and its friends are attempting to persuade the Assembly to set up a small committee of some 9 or 11 countries to study the whole problem of peaceful outer space and recommend to the 1959 session a well-considered course of action.

There is no sign that this proposal has stirred great enthusiasm. Some consider it merely a device to avoid approving a rival Soviet proposal that a space-for-peace agency be set up immediately. Such an agency may eventually emerge, but the West would not want it to be established under Soviet auspices.

Suspicions Aired

Others have a deeper suspicion that the United States is opposed to space disarmament because the net effect of such a measure might be to freeze a Soviet lead in missiles and satellites.

There is undoubtedly an element of fact in both these objections to the American plan. But there is also a case to be made for the contention that precipitate action now might involve mistakes which could have been avoided by more careful preparation.

There is also the fact that a premature commitment in principle to prohibit the use of outer space for war—such as the Soviet Union has proposed—might make it much more difficult to negotiate a control system if control were one day to be adjudged technically possible.

The example of the current Geneva talks on a nuclear test ban is continually before diplomats here. At Geneva, the Soviet Union is holding out strongly for a commitment to a permanent ban in advance of negotiations for a control system.

Effort Appreciated

Thus for a number of reasons the United States delegation here would very much like to win a thumping vote in favor of the study-and-report proposal. It would like to defeat the rival Soviet plan for paper prohibitions and an immediate agency.

Senator Johnson's eloquent speech Nov. 17 may well have helped materially. It was, in essence, an effort to persuade the committee that Washington's intentions are sincere and that establishment of a study committee would be a first step toward imaginative constructive action at a later stage.

"Until these explorations (by the study committee) are conducted," he said, "orderly procedure to the broader horizons beyond will not be possible.

United Press International

Lyndon B. Johnson

"Thus to impede this first step is to impede all progress toward goals of peace which men of faith believe exist in the realms of space," he declared.

The Soviet Union has threatened privately to boycott the study committee. It was this threat to which the Texas Senator presumably was referring when he spoke of "impeding" the "first step." The United States favors establishing the committee whether or not the Soviet Union is prepared to join in its work.

Reds Hold Out for Price

Soviet delegates have tried to "sell" their cooperation in space for peace for the price of abandonment of United States bases overseas.

"We of the United States," said Senator Johnson, "do not acknowledge that there are landlords of outer space who can presume to bargain with the nations of the earth on the price of access to this new domain."

Dr. E. Ronald Walker of Australia, a cosponsor of the American plan, said Nov. 17 that his country did not "rule out" the idea of a space-for-peace agency. But he argued that it was "premature" at this stage.

Cyro de Freitas-Valle of Brazil and Dr. Mario Amadeo of Argentina have expressed satisfaction that the American plan proclaims the right of all states, "irrespective of the stage of their economic or scientific development," to benefit from peaceful exploitation of outer space. They had urged the United States to include such a provision in its plan.

"The benefits which may derive" from outer space, the Brazilian representative said, "should in no way contribute to widening the gap between a small group of highly developed countries and the majority of nations whose most urgent problems are those related to economic development."

EDITORIAL FROM THE ST. LOUIS POST-DISPATCH
November 17-23, 1958

First Convince the Air Force

Senator Lyndon Johnson made an impressive showing of national unity when he appeared before the General Assembly to plead for a United Nations venture in outer space. He pledged support not only of the Senate majority which he leads, but of the entire membership of Congress, for the internationalization of space exploration. His voice undoubtedly added much strength to the American-sponsored resolution, supported by 19 other nations, for the appointment of a committee to study and promote international co-operation in space.

That resolution deserves to pass just as the Soviet-sponsored resolution should be defeated. The Communists, by tying the space question into a nuclear test ban and the issue of foreign bases, have made it clear that they are interested mainly in propaganda. The Western resolution at least avoids those stale disarmament disputes which the Soviets seek to renew.

But just how serious is the United States itself in proposing the international space effort which Senator Johnson so eloquently espoused? This is a good question to ask, and Senator Johnson might find it a good question to answer through the use of his powers as chairman of the Senate space committee.

Is the Air Force, for example, ready without delay to abandon its moon shots and let the U.N. make them instead? Is the Army ready to give up its own plans for circling the moon or ultimately putting a man in space? Is the new National Aeronautics and Space Agency, which is arousing so much bitterness in the military services by its efforts to recruit technical staff, ready to transfer a large part of its work to a United Nations agency?

We rather doubt that the enthusiasm for international space exploration would be as strong at these operating levels as they are at Senator Johnson's policy level. Yet it is perhaps more important that the Air Force be persuaded than that Congress be persuaded. We commend this project to Senator Johnson.

NEW YORK HERALD TRIBUNE
November 18, 1958

Johnson In Amity Plea On Space

Asks Soviets To Work With U. N.

By Joseph Newman

UNITED NATIONS, N. Y., Nov. 17.—Sen. Lyndon B. Johnson, acting as a spokesman for a bipartisan United States policy, issued a solemn call to Russia today to refrain from extending the cold war into the regions of outer space.

Addressing the Political Committee of the United Nations General Assembly, the Democratic majority leader of the United States Senate appealed to the Russians to abandon any intention they may have to proceed unilaterally into outer space.

He urged them to agree with other members of the United Nations to proceed jointly into outer space under the aegis of the U. N. flag.

Precedent Possible

He warned that the decision to be taken by the Political Committee this week could set a decisive precedent for the future approach to the vast regions beyond the earth. Sen. Johnson observed:

"If the nations proceed unilaterally, then their penetrations into space become only extensions of their national policies on earth. What their policies on earth inspire—whether trust or fear—so their accomplishments in outer space will inspire also."

He then shot these pointed remarks at the Soviet delegation sitting near by:

"For nations given to aggression and war and tyranny on earth, unilateral success in space technology would only multiply many times over their threat to peace.

"Thus it is in the interest of nations dedicated to peace and freedom that the opportunity of space not be perverted to the end of aggression and control over earth by the aggressors."

Sen. Johhnson came to the U. N. today at the request of President Eisenhower and Secretary of State John Foster Dulles for the dual purpose of displaying continuing bipartisan foreign policy and of emphasizing the desire of the United States to reach agreement with Russia on this vital issue before it deteriorates into another deadlock between East and West.

A deadlock looms as a result of two divergent proposals put before the U. N. by the United States and Soviet delegations.

The Russians will accept international action in outer space if the United States will dismantle its overseas bases and will agree not to shoot nuclear weapons through outer space.

The United States and its allies claim that these matters must be negotiated as part of the over-all disarmament problem. They proposed that the military aspect of outer space be suspended for the time being and that the U. N. concentrate on the peaceful uses of the regions beyond the earth as the

See JOHNSON—Pg. 9, Col. 7

Herald Tribune photo by Ira Rosenberg

WELCOME TO THE U. N.—Sen. Lyndon Johnson, D., Tex., taking seat offered by Henry Cabot Lodge, chief United States delegate to the U. N., before addressing Space Committee there yesterday.

Johnson

(Continued from page one)

first step toward broader agreement.

It was to prevent breakdown over these sharp differences that Sen. Johnson entered the debate today with his appeal and warning to the Russians.

Red Demand Rejected

Rejecting the Soviet demand that the United States abandon its overseas bases as the price of agreement on this issue, the Senator said:

"We of the United States do not acknowledge that there are landlords of outer space who can presume to bargain with the nations of the earth on the price of access to this new domain."

The implication of this remark is that the United States and other members of the U. N. will proceed without Russia if the latter insists on unacceptable terms.

Australian Speaks

E. Ronald Walker, Australian Foreign Minister, pointed to the important activities of his country in developing a giant radio telescope and the Woomera range from which Britain may soon launch an earth satellite.

Australia is one of the candidates for membership on a U. N. outer space committee to be composed of about twelve countries if the resolution advocated by the United States and nineteen associates is adopted by the General Assembly later this week.

The debate will continue tomorrow.

Mill press.

November 11, 1958

EDITORIAL IN THIS AFTERNOON'S BALTIMORE SUN

BIPARTISAN SYMBOL

Secretary of State Dulles' choice of Senator Lyndon B. Johnson to speak for the Administration and the United States in the United Nation's debate on the control of outer space for peaceful purposes is a good one any way you look at it.

On the level of purely domestic politics the selection may be said to show Mr. Dulles' recognition that in the recent election the Democrats took a powerful grip on both Houses of Congress. Mr. Johnson, as Democratic leader in the Senate, will command a strong majority in that Chamber. Democrats will have a large responsibility in shaping the course followed by the Country. It is only fitting that one of their own most highly responsible leaders should speak for the Country in a major discussion of the problems of space.

Then again, the appointment is a clear and direct answer to Nikita Kruschev's thesis that the Democratic victory represented a challenge to the Administration's policy in foreign affairs. Mr. Johnson himself said plainly in the midst of the campaign that foreign policy was not, and should not be, a partisan issue. In naming him to present the American proposals for a space program Secretary Dulles confirms that position. A Republican Administration entrusts the pleading of its case to a Democratic statesman--and does so with full confidence in him. It is an essay in bipartisanship which the world will not overlook.

Finally, Mr. Johnson is admirably qualified to accept this particular task. He has addressed himself many times during the present year to the serious questions posed by the world's entrance into the "space age." He is Chairman of the Senate's Space and Astronautics Committee. The subject is one which he has studied and in which he is deeply interested. So, not only will he appear before the General Assembly as a symbol of American agreement beyond any political considerations; he will also appear as a man well qualified to take an important part in the discussions.

As we have said, it is, in all ways a good appointment.

PHILADELPHIA INQUIRER
November 9, 1958

"MAKES ME FEEL MIGHTY GOOD"

Teamwork—the Nation's Need

Senate Majority Leader Lyndon Johnson's pledge that the new, overwhelmingly Democratic-controlled Congress will meet President Eisenhower "at least halfway" in an effort to make the next two years a period of constructive achievement is precisely the kind of statement the American public has wanted since Election Day.

Without in the least doubting the sincerity of Senator Johnson, or of House Speaker Sam Rayburn who similarly promised that Congress will follow a constructive course, it must be remembered that the real test of the intentions of the new Congress cannot lie in the statements of its leaders.

But the cooperative attitude reaffirmed by the two Texans who have led their respective houses of Congress for the past four years is immensely reassuring after an election which changed the make-up of the legislative body from one where bipartisan cooperation was necessary to obtain most action to one in which one party will have unquestionable power—and responsibility.

The elections left no doubt that the Democrats will have the votes in both the Senate and House to pass just about any legislation they please. With the addition of a few Republican votes, they would have power to override Presidential vetoes.

Moreover, the precise policies and intentions of the newly elected Senators and Representatives are at this point unknown. The addition of large numbers of new Democratic Congressmen not only gives the leaders more votes; it also may give those leaders greater problems in formulating programs that are satisfactory to all wings of the party.

Senator Johnson wisely and realistically recognized that the Democratic sweep in Congress does not alter the essential responsibility for handling foreign policy, when he pointed out that Mr. Eisenhower has been chosen as our President for two more years and that "a Nation cannot exist in the field of foreign affairs and defense when it speaks with two voices."

This sensible statement was paralleled by one from Secretary of State Dulles, who expressed confidence that he will be able to work with the new Democratic Congress to continue the fundamental bipartisanship of our foreign policy.

Without question, maintaining imaginative and effective foreign policy and enacting the legislation to make it work will be one of the big jobs of the new Congress. But there are domestic needs as well, and it is in handling these that Congress will have its willingness to cooperate with the President put to severe tests.

The great problems of exploding population, breath-takingly swift advances in technology, and the challenge of outer space, which involve the Nation as a whole, are producing a long list of detailed demands upon the Government. In addition, unsolved problems from the past remain, such as that farm income and surpluses, and the cancer of union racketeering.

It is in meeting these that the new Congress will run up against a particularly dangerous question—that of fiscal stability. Each demand for Government action is likely to involve greater spending. Yet the present budget of $80,000,000,000 is threatening to produce a huge deficit, and further deficits could feed the inflation which undoubtedly is one of the chief worries of the American people.

Cooperation, not just in passing legislation, but in formulating programs and weighing their impact on the Nation's fiscal stability, will be absolutely essential if the Democratic Congress and the Republican Executive are to achieve constructive results.

President Eisenhower has based his career in office on the belief that teamwork is the key to the kind of Government Americans want. With the large Democratic majorities controlling Congress, that teamwork may be harder to maintain. But we are confident, with Senator Johnson and Speaker Rayburn leading the way, that constructive cooperation can assure the Nation's continued progress over the next two years.

NEW YORK HERALD TRIBUNE
November 19, 1958

Lyndon Johnson As Statesman

There are no differences within our government, between our parties or among our people. . . .

That was Lyndon Johnson, leader of the President's loyal opposition, speaking—speaking to the world, and on the specific subject of outer space. His forum: the eighty-one nations comprising the United Nations.

After the Democratic political landslide, certain leaders abroad—notably Nikita Khrushchev—got the notion that the American voters had repudiated U. S. foreign policy.

The leader of the Democratic majority in the Senate had come to the U. N. to let all nations know, emphatically, otherwise. He came at the request of Ambassador Lodge, reinforced by subsequent invitations by the Secretary of State on behalf of the President. He came to speak on the need for international control of outer space, a matter in which Johnson has taken intelligent and perceptive leadership from the outset.

Johnson's appearance and eloquent performance undoubtedly made a deep impression on the uncommitted nations. The Soviet decision to backtrack on its opposition to space control was probably hastened by such Johnsonian arguments as these:

"If the nations proceed unilaterally, then their penetrations into space become only extensions of their national policies on earth. What their policies on earth inspire—whether trust or fear—so their accomplishments in outer space will inspire also.

"For nations given to aggression and war and tyranny on earth, unilateral success in space technology would only multiply many times over their threat to peace."

We congratulate Senator Johnson for this forceful affirmation of U. S. policy. At a New York luncheon yesterday, he also pledged his intention to lead the now massive Democratic Senate majority on moderate, and not extremist, courses and to do his utmost to work with the Republican executive branch in a united approach to the major problems of the nation. "I count myself a free man first," he said, "an American second and a Democrat third." Senator Johnson is unquestionably a man of stature, a master of political statecraft and of compromise, a wizard at the maintenance of unity among warring and divergent forces. In the two years ahead of even more disproportionate divided rule, he has a genuine opportunity to make the most of his qualities of leadership and genius for compromise. By putting the national interest above petty partisanship he can rise to true statesmanship.

NEW YORK HERALD TRIBUNE 11/19/58

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THE WASHINGTON POST
November 19, 1958

Johnson to Dulles

Sen. Lyndon Johnson's assurances that there is bipartisan support for the Administration's proposal that outer space be dedicated to peaceful purposes undoubtedly came as no surprise to the Soviet Union. A favorite Russian *riposte* to charges that the Soviet state is a political monolith long has been that in all important aspects of foreign policy the United States, too, in effect has but "one party." This is of course a misleading oversimplification of the way in which bipartisanship works in these matters—but it is true that serious dissent on basic foreign policy objectives is seldom undertaken lightly and virtually never in an overseas or international forum.

But though there was nothing surprising in the Johnson statement to the United Nations General Assembly, this clear and firm declaration was useful and timely coming after the sweeping Democratic election victory. It should strengthen the Administration's hand not only in the Assembly but in the Geneva talks on surprise attack. And it ought also to lay the groundwork for broadened and fruitful consultation with the Democratic leadership in the new Congress. In this respect what Senator Johnson said should have more significance for Secretary Dulles than for the Russians, and we hope the invitation to real cooperation with the Administration which it bespeaks will not be lost on Mr. Dulles.

WASHINGTON EVENING STAR
November 18, 1958

No Politicking in Space

In effect, in his good and timely address to the United Nations, Senate Majority Leader Lyndon B. Johnson has cautioned the world against misinterpreting the meaning of the Democratic sweep in our recent congressional elections. He has made clear, for one thing, that the overwhelming majority of the American people, despite the Republican defeat, firmly supports the Eisenhower administration in all vital areas of foreign policy, which is and has long been an essentially nonpartisan matter.

More specifically, in connection with the current U. N. debate on efforts to promote world co-operation in beneficent spatial projects, Mr. Johnson has unqualifiedly emphasized that our country, regardless of partisan divisions on domestic problems, is wholeheartedly in favor of the President's proposal for such co-operation. As the Senator has put it, "On the goal of dedicating outer space to peaceful purposes for the benefit of all mankind, there are no differences within the Government, between our parties, or among the people. . . . United we stand."

Since these are words spoken by one of our most powerful political leaders—a Democrat who will continue to be a towering figure in Congress while the White House remains Republican—nobody abroad should make the mistake of brushing them aside as mere oratory. For what Mr. Johnson has said is the truth: American domestic politicking stops at the edge of space, just as it has always stopped at the water's edge in the field of crucial foreign policy.

WASHINGTON STAR
November 19, 1958

'Sorry, That Pass Is No Good Here....'

THE NEW YORK TIMES
November 18, 1958

In Essentials, Unity

What Senator Lyndon Johnson said yesterday, before a United Nations committee, about what he called "the essential unity of the American people," was even more important than the resolution with which he was dealing.

Senator Johnson, indeed, was appealing for "full and complete and immediate cooperation to make the exploration of outer space a joint adventure." He was trying to convince the unregenerate that "penetration into outer space is the concern of all mankind." He was laying down the principle that "we of the United States do not acknowledge that there are landlords of outer space who can presume to bargain with the nations of the earth on the price of access to their new domain." He was holding up before our baffled and worried race a new ideal and hope: "Men who have worked together to reach the stars are not likely to descend together into the depths of war and desolation."

The resolution for which he spoke could alarm no reasonable man. It calls for a mobilization of the resources of the United Nations, for international cooperation under U. N. auspices, for a study of the legal problems involved in "this joint adventure among the nations of the earth." It proposes a U. N. study committee of nine members to examine the means of exploring what Ambassador Lodge called "this new dimension."

But the majority leader of the Senate did not have to come to U. N. headquarters to present arguments which other men might have phrased just as effectively. He came to demonstrate that, although the recent election strengthened his own party and weakened the President's party, both parties, in the Legislative branch as well as in the Executive branch, could and will work together. There is no division on ideals of peace, no quarrels that will interfere with our responsibilities in the world at this critical juncture.

A final word should be said for Lyndon Johnson himself. He came to U. N. headquarters yesterday not as a partisan, not as an ambitious politician, but as a patriot and as a good citizen of the world. In that role we salute him.

BOSTON TRAVELER 11/19/58

Policies Of Space

WHEN Sen. Lyndon Johnson addressed the United Nations this week, he was calling for action to stop the cold war from being extended into outer space.

That can be done. But it can be done only if the UN membership supports the proposal, and if Soviet Russia agrees not to charge forward singlehanded with space policies.

JOHNSON

As Johnson pointed out: "Today outer space is free. It is unscarred by conflict. No nation holds a concession there. It must remain this way."

We doubt that the Soviets will go along with the idea that all nations should act together in the conquest of space. Certainly they won't accept that plan without a lot of argument.

But at least we have given them something to think about in demonstrating that our own policies on space are handled on a bipartisan basis.

Here we had Johnson, a strong Democratic leader, co-operating with G.O.P. leaders Eisenhower, Dulles and Lodge in making his UN appearance. On our probings into outer space, we stand united and above political bickerings. Our hope is simply that international differences can be put aside as successfully, so that space policies will react to the benefit of all mankind.

This is a subject that should remain above all arguments about missile tests and overseas bases.

The common goal of all nations should be to keep space free for peaceful purposes.

WASHINGTON POST
November 18, 1958

Nation 'United' On Space Issue

By Milton Besser

UNITED NATIONS, N. Y., Nov. 17 (AP)—Senate Majority Leader Lyndon B. Johnson told the U. N. today that both the Democratic and Republican Parties solidly support President Eisenhower's proposal for international cooperation in control of outer space.

The Texas Democrat gave the U. N. that assurance in an unprecedented appearance before the 81-nation Political Committee.

He came here at the invitation of Secretary of State John Foster Dulles to underline United States solidarity on a top foreign policy issue. It was the first time a leader of the political opposition had addressed the U. N., although the United States delegation includes both Republicans and Democrats.

Johnson, who is among those mentioned as a possible Democratic nominee for the Presidency in 1960, told the Committee:

"On the goal of dedicating outer space to peaceful purposes for the benefit of all mankind, there are no differences within our Government, between our parties, or among our people.

"The executive and the legislative branches of our Government are together. United we stand."

He urged the U. N. to support the United States proposal for establishment of a special committee to explore all aspects of cooperation in peaceful use of outer space, and to report back to next year's General Assembly.

He said the principle of international cooperation was written into the law creating the United States agency under civilian control to promote exploration of outer space.

Johnson's speech was sandwiched between two Communist attacks on United States policy. Romanian Delegate Silviu Brucan spoke before Johnson. K. V. Kiselev, the Byelorussian Foreign Minister, followed him.

But Johnson was so busy being introduced to various U. N. delegates he did not have much time to listen. Kislev commented that Johnson's speech contained nothing new.

WASHINGTON EVENING STAR
November 18, 1958

OUTER SPACE WENT THAT-AWAY

Henry Cabot Lodge, head of the United States delegation to the United Nations, points out something of interest for Senate Majority Leader Johnson after the Texas Democrat jointed in the United Nations' outer space debate. Senator Johnson told the General Assembly's 81-nation Political Committee Americans are solidly behind the Eisenhower administration's proposal for international co-operation in outer space. He said outer space is free today and it must remain so.—AP Wirephoto.

HOLD FOR RELEASE FOR A.M. PAPERS SUNDAY, FEBRUARY 12, 1967 FEBRUARY 9, 1967

Office of the White House Press Secretary

THE WHITE HOUSE

The President's Science Advisory Committee today submitted to the President a report entitled "The Space Program in the Post-Apollo Period." The report was prepared by the combined Space Science and Space Technology Panels of the Science Advisory Committee chaired by Dr. Franklin A. Long, with Dr. Lewis M. Branscomb as co-chairman.

The Panels rejected the adoption of a single new dominating goal for the space program but recommended a balanced program based upon the expectation of eventual manned planetary exploration, integrating manned and unmanned efforts directed toward the following major objectives:

1. A limited but important extension of Apollo in order to exploit our anticipated ability to explore the Moon.

2. A strongly upgraded program of early unmanned exploration of the nearby planets, on a scale of time and effort that will enable the results of this program to contribute significantly toward the planning of future manned expeditions.

3. A program of technology development and of qualification of man for long duration space flight in anticipation of manned planetary exploration.

4. The extension and vigorous exploitation of space applications for the social and economic well-being of the nation and for national security.

5. The exploitation of our capability to carry out complex technical operations in near earth orbit for the advance of science, particularly astronomy.

For each of these major areas, the report presents a discussion of alternative possibilities and a set of detailed recommendations. The principal recommendations are:

MORE

Lunar Exploration.

1. Continue manned expeditions at an initial rate of one or two per year, with each manned expedition provided sufficient logistics support to permit a stay time of several days and astronaut mobility of several miles to provide for study and exploration of interesting features of the Moon.

2. Provide unmanned lunar landers during the early 1970's capable of landing significant scientific payloads anywhere on the Moon.

Planetary Exploration

The report includes the following recommendations involving future planetary exploration:

1. That NASA conduct as soon as possible a carefully integrated study of the relative effectiveness of man in planetary flyby and orbiter missions to the near planets, considering manned and unmanned modes in all relevant combinations. An integral part of this study should be a consideration of how the unmanned Voyager concept might be made compatible with possible manned planetary ventures in the late 1970's.

2. That the Voyager planetary lander program directed toward an unmanned soft-landing on Mars in 1973 or 75 be supported. This program should include planning for the possibility that a Voyager mission to Venus (involving the option to land on Venus if this is possible) may receive a high priority during this period.

3. In the general context of an expanded unmanned planetary program, that a 1970 Venus mission to probe the atmosphere of this planet be given particular consideration as the next new planetary mission.

MORE

Biomedical Studies

The report points out that biomedical studies of man in space will be required before long duration interplanetary flights can be undertaken and the principal recommendations in this area are:

1. That programs in earth orbit be established to determine the effect of prolonged exposure of man (about 100 days or more) to the space environment, to learn how to predict these effects for individuals not yet exposed, and to devise ways to ensure and improve man's effectiveness.

2. That the proposed orbital workshop experiment of the Apollo Applications Program proceed. The launch vehicle and spacecraft are already on order and the opportunity for 28-56 day flights in 1968 should be seized.

3. That arrangements be developed between NASA and the USAF to use the MOL program as an important source of data on the capabilities of man for extended space missions to supplement information from early AAP missions.

4. That a program of study and advanced development be initiated promptly with the objective of a launch in the mid-1970's of the first module of a space station for very prolonged biological studies of man, animals and other organisms in earth orbit.

Space Applications

The report recommends:

1. That a far more intensive effort be carried out to examine the applicability of satellite technology to the missions of all the Federal agencies.

MORE

2. That, whether the proposed space application systems are manned or unmanned, a reasonably clear case of potential benefit should be shown to exist before significant developmental costs are assumed and, further, relative cost effectiveness criteria should be used in decisions between manned and unmanned operational systems.

Orbital Space Science.

The report identifies one area, that of astronomical observations in space, as being so rich in possibilities for advancement in knowledge that it can well serve as the major scientific focus of the U. S. space program in the 1970's. The recommendations are:

1. That the government adopt as a primary goal in the application of space technology for scientific purposes a program of research leading to the establishment in earth orbit of a number of astronomical facilities, which by the end of the 1970's will constitute an orbiting astronomical observatory capable of: (a) taking advantage of the regions of the spectrum not accessible from the ground as well as other advantages of instruments in orbit such as much higher resolution; (b) scientific control directly by astronomers on the earth; (c) extended useful life through intermittent maintenance and modernization by servicing in orbit. This program should be evolutionary with each step big enough to be significant but not so grandiose that it cannot be modified as new discoveries and technological advances become available.

2. That NASA should develop arrangements for working with the scientific community to permit the most effective use of the investments in this astronomy program.

International Cooperation.

The Panels recommend increased emphasis on international cooperation as the space program develops. They urge that all agencies having related interests actively support international programs in space involving the fostering of cooperative efforts through organizations such as the International Council of Scientific Unions.

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EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY
WASHINGTON, D.C. 20506

EXECUTIVE (4)
OS
FG 726
FG 11-9
PR 18-3
FG 11-8-1/Watson, Marvin

X

February 13, 1967

MEMORANDUM FOR

Mr. W. Marvin Watson

The attached report was publicly released by the White House on February 12, 1967, and is supplied for your information.

Russell C. Drew
Russell C. Drew
Technical Assistant

Attachment

2 Booklets filed: Oversized attachments

1400

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FG 11-8-1/Califano, Joseph A.

EXECUTIVE OFFICE OF THE PRESIDENT

OFFICE OF SCIENCE AND TECHNOLOGY

WASHINGTON, D.C. 20506

February 13, 1967

MEMORANDUM FOR

Mr. Joseph A. Califano, Jr.

The attached report was publicly released by the White House on February 12, 1967, and is supplied for your information.

Russell C. Drew

Russell C. Drew
Technical Assistant

Attachment

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JOE CALIFANO, JR.
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EXECUTIVE
OS
FG 726
FG 11-9
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FG 11-8-1/Levinson, Lawrence

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY
WASHINGTON, D.C. 20506

February 13, 1967

MEMORANDUM FOR

Mr. Lawrence Levinson

The attached report was publicly released by the White House on February 12, 1967, and is supplied for your information.

Russell C. Drew
Russell C. Drew
Technical Assistant

Attachment

THE SPACE PROGRAM
IN THE
POST-APOLLO PERIOD

A Report of the
President's Science Advisory Committee

Prepared by the Joint Space Panels

THE WHITE HOUSE
FEBRUARY 1967

THE SPACE PROGRAM
IN THE
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President's Science Advisory Committee

Prepared by the Joint Space Panels

THE WHITE HOUSE
FEBRUARY 1967

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 50 cents

THE WHITE HOUSE

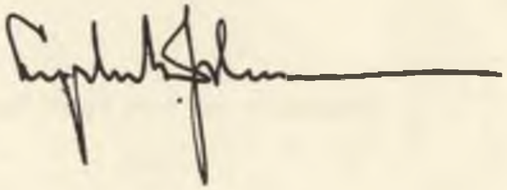
WASHINGTON

January 11, 1967

In the brief span of less than ten years, the United States Space Program has advanced from small and hesitant beginnings into a large and vital national effort. Today, its achievements provide daily testimony of our country's leadership in space capabilities, in their applications to peaceful practical purposes, and to the advancement of scientific understanding of the world in which we live.

But space is a hostile medium both for man and his instruments and therefore long periods of study, planning and hard work are required before major space undertakings can be successfully executed and their benefits fully harvested. For this reason, my Science Advisory Committee during the last year has been examining the many faceted problem of what the United States might do in space in the early years following our Apollo Program. They have examined the potentialities and the value of new space programs and recommended a course for the future.

We will give careful consideration to these recommendations. Because the opportunities in space are great but the costs are high, our space planning deserves the thoughtful consideration of all Americans. I am therefore releasing this report for publication so that the excellent work of this Committee will be available to all as we chart a course into the future.



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Glossary

AAP—Apollo Applications Program
ABL—Automated Biological Laboratory
Airlock—An assembly which may be mounted on the forward portion of the SIVB stage, providing multiple docking positions, extra life support and cryogenic supplies, and a tunnel through which access may be gained to the empty fuel tanks of the SIVB stage
AOSO—Advanced Orbiting Solar Observatory
Atlas/Centaur—Launch vehicle with an Atlas first stage and a Centaur upper stage capable of placing 8,500 pounds in a 300-nautical-mile orbit
ATM—Apollo Telescope Mount (a term presently used to describe the manned solar astronomy project)
COMSAT—Communications Satellite Corporation
CSM—Command and Service Module of the Apollo System
EMR—Electromagnetic Radiation
ESSA—Environment Science Services Administration (Dept. of Commerce)
EVA—Extravehicular activity
LLM—Lunar Logistics Module
LM—Lunar Module of the Apollo System (formerly called the Lunar Excursion Module)
M—Millions of dollars.
Mariner—Unmanned spacecraft used in planetary exploration
MOL—Manned Orbiting Laboratory (Department of Defense)
NAS—National Academy of Sciences
NSF—National Science Foundation
OAO—Orbiting Astronomical Observatory
OART—NASA Office of Advanced Research and Technology
OGO—Orbiting Geophysical Observatory
OMSF—NASA Office of Manned Space Fight
Orbital workshop—The combined assembly of the Airlock and the SIVB spent stage of the Uprated Saturn I launch vehicle
OSSA—NASA Office of Space Science and Applications
PSAC—President's Science Advisory Committee
Saturn V—Apollo launch vehicle consisting of three stages—the S–IC, the S–II, and the S–IVB—capable of placing about 250,000 pounds into low earth orbit
S–IVB—The liquid hydrogen-liquid oxygen upper stage of the Saturn V and the Uprated Saturn I launch vehicles
S–IVB Spent Stage—The S–IVB stage after propellant burn out
Surveyor—Spacecraft designed to soft-land payloads on the moon

Telefactor—A remotely controlled system capable of independent motion and manipulation

Titan III—One of a series of launch vehicles based upon the Titan II with the addition of a transstage and various strap-on solid rocket booster configurations. A Titan IIIM, for example, is capable of placing about 39,000 pounds into low earth orbit

Uprated Saturn I—Launch vehicle consisting of an S–IB first stage and an S–IVB upper stage capable of placing about 42,000 pounds into low earth orbit

Voyager—An unmanned spacecraft planned for advanced planetary missions to either Mars or Venus

Zero-g—Free from net accelerations (or forces)

Section I. Introduction

Background.—The U.S. space program in 1967 is on the eve of new major accomplishments and, at the same time, is at a crossroads of crucial choices for the future.

The major U.S. programs of manned space flight have all gone well. The Mercury program was successful. The much more elaborate Gemini program has just been completed with astonishing success. The still more ambitious Apollo program for a manned lunar landing is going well and there is a good probability of attaining a lunar landing by the end of 1969.

The programs of space science and space applications have been extensively developed and some aspects of the applications programs have been taken over by the relevant agencies, e.g., meteorology by Environmental Science Services Administration (ESSA). In one important area, civilian communications, a unique enterprise, Comsat, has been established.

There is also a very substantial space program in the Department of Defense. Although many of its accomplishments are necessarily classified, there is every indication that this program, too, is going well.

In the process of carrying out the many projects within these space programs the United States has developed a large group of space-oriented facilities and a large body of experienced people. A great competence for construction of space vehicles and equipment has been developed within U.S. industry. Finally, there is now available a very substantial set of tested and reliable space launch systems ranging from the small efficient Scout vehicle to the very large Uprated Saturn I and Titan III launch systems which are capable of putting over 30,000 pounds into low earth orbit. Shortly, it is expected that the Saturn V, capable of placing a 250,000-pound payload into earth orbit, will join the inventory.

The significance of these facts is that with the termination of the basic Apollo project now only 3 years away it has become urgent to begin planning for the post-Apollo space program, i.e., the space program of the decade of the 1970's and later. A further component of the urgency is that because of the long leadtimes associated with major space efforts many of the possible programs for the 1970's will require initial funding in the near future.

It was in this overall context that Dr. Hornig requested the PSAC Panels for Space Science and Space Technology jointly to study the problem which can be summarized as: Where do we go in space from here?

Current status of the U.S. space program.—By far the largest part of the the U.S. space program is conducted by the National Aeronautics and Space Administration. About 25 percent of the total effort is conducted by the

Department of Defense; the efforts of such other groups as the Atomic Energy Commission, ESSA, and NSF amount to only about 3 percent. NASA conducts its widespread operations from a series of major facilities, many of which have been constructed or put into operation only during the last few years, e.g., the great launch facility at Cape Kennedy.

The organizational structure of NASA is complex. There are a number of large Centers which conduct and manage both research and development programs and major industrial contracts, plus a substantial Headquarters operation with four program offices: Advanced Research and Technology, Space Science and Applications, Manned Space Flight, and Tracking and Data Acquisition. From a budgetary standpoint the Office of Manned Space Flight (OMSF) is substantially larger than all the other offices combined. It is OMSF which has responsibility for the Gemini and Apollo programs, both of them large and costly. The considerable success of these efforts is a tribute to the capabilities of OMSF and to the degree with which effective cooperation has been developed between the Headquarters Offices and the relevant Centers.

The 1967 program for NASA is $4.908 billion (which includes a $60 million reduction in funding available to the agency, to be carried forward into fiscal year 1968). The following table summarizes the planned use of the fiscal year 1967 funds:

Program area	*Fiscal year 1967 NASA program (in millions)*
Manned Space Flight	$3,398
Scientific Investigations	560
Space Applications	112
Space Technology	385
Aircraft Technology	103
Supporting Operations	350
Total	4,908
NOA Adjustment	+60
Total Appropriated by Congress	4, 968

Virtually all of the items within manned space flight are for the Gemini and Apollo programs. Funds for the latter program will stay high in 1968, drop considerably in 1969, and become relatively small shortly thereafter unless a new manned flight program is instituted soon.

A new program, Apollo Applications (AAP), covers the work being done in preparation to use the Apollo space system once a successful lunar landing and return have been achieved. Herein lies one of the awkward aspects of program planning at this time. In order to give a high probability that Apollo will be successful by 1970, NASA has on order 12 Uprated Saturn I launch systems and 15 of the larger Saturn V launch systems, the one which

will be used for the moon mission; also on order are 20 Command and Service Modules (CSM) and 15 Lunar Modules (LM) to go along with these launch systems. There is a reasonably high expectation that only 8 of the Uprated Saturn I's will be needed for direct support of the Apollo program and that a successful manned lunar flight will have occurred well before 15 Saturn V's are launched, perhaps as early as the seventh. In other words, it appears necessary to do contingency planning for use of some of the Uprated Saturn I and Saturn V launch vehicles as well as some of the CSM and LM payloads, even though they cannot yet be definitely freed for AAP use.

The Space Science and Space Applications programs of NASA have been funded at considerably more modest budget levels, as indicated above. Nevertheless, the scientific results have been highly rewarding. From studies with sounding rockets, balloons, and especially orbiting satellites we now know very much more than ever before about our earth and its atmosphere, about the sun, moon, and planets, and about the properties of deep space. Much more exciting science remains to be done.

We have made significant progress in creating operational satellite systems for practical use in meteorology and civilian communications; a number of other interesting possibilities are under study.

Since, in addition to all this, NASA has developed almost from scratch the very large managerial system by which these programs have primarily been directed, it is from a position of strength and accomplishment that NASA turns to the question of the space activities of the 1970's. NASA understandably feels that it has fully demonstrated the capability to carry out virtually any major space program that it and the Nation may devise.

The current situation for the space program of the Department of Defense is somewhat different. This program, too, is large: $1.6 billion in fiscal year 1967. Much of it, however, concerns space applications of direct and continued military interest, two examples being navigation and military communications. The need for continued development and use in these areas will surely remain and hence guarantee DOD a continuing role in space. DOD, however, has other development programs whose future character is less definite and which occasionally are closely parallel to NASA activities. One such program is the development of the Titan III rocket launch system. This is a family of launch systems whose capabilities are rather like those of NASA's Uprated Saturn I. One projected use of the Titan III is to launch a series of Manned Orbiting Laboratories (MOL), during the course of which DOD will gain considerable experience on man's capabilities in space. Initial launch of MOL is scheduled for late 1969 or early 1970.

The other U.S. space programs are much smaller than these two. AEC has a large and important program in nuclear power and nuclear propulsion for space use ($181 million in fiscal year 1967). ESSA is taking over applications of space to meteorology and related problems but its budget is is still very small.

In sum, then, the U.S. space program is very substantial, involving a budget of $6.7 billion in 1967. A fundamental question is "What does the Nation expect in return for this expenditure?" Some answers to this question are considered in section II of this report.

Section II. Rationale of the U.S. Space Program

Introduction.—The vigorous and productive space effort which has been developed in the past several years makes it possible for the United States to select from a broad spectrum of choices in planning its future space programs. Furthermore, the selection and planning can be firmly based on a wide range of experience with different rocket launch systems and different space probes. The United States has the opportunity, in other words, to devise for the 1970's a number of rather different space programs. The vital questions which must be faced are: What benefits are derived from the national space program and what goals will best serve these ends? In this section the Panels give their own answers to these questions with, however, full recognition that their answers are necessarily developed from a particular point of view, reflecting their background and experience in science and technology. The final answers must necessarily be based on a much wider group of judgments concerning the purposes and benefits of space activities.

The Panels also realize that, in a certain sense, space programs can be thought of as competitive with other quite different programs, for example, in oceanography, improved transportation, or in urban renewal. Comparisons among these different programs go well beyond the competence of the Panels. It is with full recognition of these complexities that the Panels have addressed themselves to the rationale of the space program itself.

A fundamental consideration in discussing the U.S. space program is that since it is undertaken for many reasons a cost analysis of its benefits has only limited utility. For certain applications, e.g., the use of satellites in a storm warning system, cost analysis is feasible, if inexact. For other applications cost analysis is less easy. Some benefit analyses of the impact of the space program on the state of U.S. technology and on the development of new technologies can perhaps be made. But for most of the major space goals such quantitative judgments are simply not possible. How can we attach a dollar value to the attainment of a position of leadership in space? What of space exploration—what value can one attach to the excitement and the general stimulation of the national spirit that results from a manned lunar landing? And what of space science? How can one put a quantitative value to the development of an absolutely new astronomy or to the discovery of life on another planet? In the next paragraphs the Panels discuss some of these goals and their implications in the planning of U.S. space programs for the 1970's.

Leadership in space.—Our vigorously expanding space capability is the product of a national commitment to respond to the early lead of the USSR in space technology. Not only was the challenge of Sputnik met, but major efforts were simultaneously launched to seek excellence in education and improvements in the quality of American life upon which depends the prominent position of our society among those of other nations. The U.S. space program has produced significant scientific discoveries and has demonstrated great effectiveness in developing practical uses of space. We have every reason to believe that our Apollo program will be successful on a time scale which is fully competitive with that of the USSR. In a number of areas of space activity it is now reasonable to say that the United States has attained a position of leadership. Should, however, the USSR continue to press forward in space exploration as vigorously as they have in the past, a continued strong effort will be required by the United States if we are to maintain our present position. Indeed, should the much more intensive efforts that the USSR has been giving to unmanned planetary exploration begin to prove successful, an expanded effort on our part will be necessary to avoid relinquishing leadership in this area.

The consequences of a loss of a leadership position in space exploration are not so likely to be a severe blow to the nation as was the shock of the first Sputnik and later the first manned orbital flight by the USSR. But the Panels do not believe that this nation wishes to accept such a secondary role voluntarily in the face of the opportunities now open to us. In addition, from a longer term viewpoint, the maintenance of a competitive posture with the Soviet Union may facilitate collaboration on a scale which could not only advance the peaceful exploration of space but also contribute to world stability.

Nonetheless, we do not believe that any particular set of space goals, short of an all-out U.S. effort towards all major space objectives at a rate limited only by technology and production facilities, will guarantee a publicly convincing demonstration of U.S. superiority in space. Nor do we believe that such "assurance" is necessary as long as our goals are chosen to reflect national aspirations and needs. A program based on such goals will have the advantage of remaining valid and worthwhile even if the USSR should drastically reduce its efforts.

We see the objectives of the U.S. activities in space for the next decade as falling into two major categories, both important, but involving rather different benefits to the nation and requiring different levels of effort: the practical uses of space, and space exploration, including space science. We will discuss them in sequence, and then consider some indirect benefits from both.

Practical uses of space.—From the earliest days of the U.S. space program the new capabilities have been put to use rapidly for both civilian and military purposes. On the military side, for example, in navigation and communications, the applications have been extensive and of great importance to our security. The experience of both the Department of Defense and of

NASA has provided an excellent opportunity to examine the potentialities of space operations for defense, and the range of possibilities for unmanned space systems is now substantially understood. The MOL program will provide a better understanding of the potentialities of the use of manned space flight for military purposes.

In the area of non-military uses of space, the program of space based communications has been a notable success: conduct of these operations has been carried out in the private sector, but with support from government funded research and exploratory development. Perhaps the most important potential use of space is in the area of environmental prediction and control. Weather satellites have been in operation for several years and have proved particularly useful in storm warnings. The thrust of much of the space research devoted to understanding the earth and its environment is directed at providing a basis for future practical uses of space.

These programs of space applications, and the research which is devoted to exploring the future possibilities, constitute about a third of our present total space effort. The majority of this effort is in DOD, but applications have begun to be explored by other Departments, such as Commerce. They constitute a very important part of our space effort, and in the narrow sense are its short-term payoff. Nonetheless, the total magnitude of the effort, while perhaps deserving of expansion, must be scaled to the value of the present and likely future benefits, using comparison with alternative ground-based technology when available as the basis of evaluation. Thus while "cost-effectiveness" criteria are not always quantitatively applicable to space applications programs, justification of the programs should still be based directly on material benefits to our society.

Space science and exploration.—Space exploration directed at scientific and other goals is not entirely distinct in its nature and benefits from the projects conceived in terms of specific applications. The scientific results from research in near earth space during recent years finds many points of direct utility in the applications programs. Nonetheless, the scale of costs in the present Apollo program or in other manned endeavors of similar magnitude cannot be proved commensurate with the direct benefits to be derived from them in the future. And the prospect of manned planetary exploration appears to take us into areas of technology where the value for applications is less evident than from earth orbital activities. Thus we must consider values beyond those of direct material benefits.

The first PSAC public paper on space, "Introduction to Outer Space," in 1958, eloquently described the intellectual and human appeal of space exploration. The Panels feel that the challenge of exploring the unknown is still the primary motivation for the majority of our current space efforts. It becomes a more compelling motive as we better understand the opportunities ahead. We do not find it easy today to be much more sophisticated than before in our understanding of the human aspiration to explore the unknown. But it is clear that, for the second decade in space, our previous experience and success permit us to concentrate more heavily on the goals of space exploration rather than its uncertainties and difficulties. *Furthermore, as we develop programs of space exploration, their interest and value to the nation can be greatly enhanced by planning the programs to maximize their scientific return.* For this reason we shall discuss the basis for assigning scientific priorities to project goals.

To the Panels the most challenging scientific goals of space exploration are those which touch on fundamental scientific questions of considerable philosophical content. In essential agreement with the Space Science Board of the National Academy of Sciences we take these questions to be:

1. Does life abide in places other than the earth, and if so what is its nature, how did it evolve and what are its probable forms elsewhere?
2. What is the origin and evolution of the universe, and what is its ultimate destiny? What is the place of our sun and solar system in it? Do natural laws as we know them on earth indeed govern the behavior of every observable part of the vastness of space?
3. What are the physical conditions on the moon and on the other planets in our system, and how did our solar system evolve? What dynamic relationships between the sun and the planets shape their environments?

Not only the intrinsic importance of these questions, but also the opportunity to learn concrete facts which may shed light on their answers convinces us that the space exploration program should be formulated to attack them vigorously and efficiently. Contributions to these objectives have thus far been made principally through the unmanned space science program, since the current manned program has the primary objective of a lunar landing and return. During the next decade in space the Panels hope that manned and unmanned technologies will be wedded together more effectively to attack these fundamental scientific questions.

Much of the significant space science that will be done in the next decade will continue to be accomplished from earth orbiting systems. There will be fundamental biomedical and engineering studies which become feasible only in a gravity-free environment. There will be observational research programs directed toward the earth and its environment. Finally, and of particular interest, there will be uniquely significant astronomical observations which take advantage of the absence of the atmosphere which is opaque in most regions of the spectrum and distorts the images produced by fine telescopes. Many of the scientific results of these earth orbiting experiments will provide the basis for future space applications. The astronomy programs, in particular, are expected to contribute importantly to some of the most fundamental scientific problems of our time, i.e., the origin of the universe and the basic laws which govern its behavior. In terms of fundamentality of the experiments and comparative cost, many of these space

science experiments can be reasonably considered competitive with some of the major experiments and equipment now contemplated for earth-based installations in other fields of science. It remains true that space science is normally costly, but for well planned experiments which exploit the unique opportunities that space affords, the scientific return can be very large. A coordinated program of space astronomy in which unmanned satellites play a large role, and where man will be appropriately used to obtain long trouble-free and efficient utilization of the complex scientific equipment, will, in the Panels' judgment, be one of the most significant and fruitful scientific programs of the coming decade.

Programs of science and exploration directed toward Mars, Venus, and the other planets will be of major importance in the 1970's. They will be technically demanding, scientifically exciting, and will offer intriguing possibilities for interactive use of unmanned and manned space flights. In planetary studies undertaken through voyages to the vicinity of the planets, preliminary scientific results can probably be obtained more efficiently and quickly through a vigorous unmanned planetary program. However, the eventual participation of man in the surface exploration of these planets seems an essential part of the full investigation of extra-terrestrial life. If encouraging results are obtained from early unmanned explorations of one or more planets, along with continuing ground-based studies and studies of man's reaction to long duration space flights, such manned flights to the planets could be attempted. A national decision to pursue this possibility could ultimately be of great scientific significance if the efforts are planned to maximize the scientific return.

Consequently, the Panels believe that an attractive long-term objective for space exploration is a program directed ultimately at the exploration of the planets by man. In spite of the great difficulty and considerable hazard of this enterprise, we support a program directed toward its accomplishment because we believe the question of extra-terrestrial life to be of great significance to scientist and layman alike, and believe it likely that man's presence may ultimately be required to provide full and satisfactory answers.

In arguing for a continued national effort in space science and exploration, we appreciate that the expenditures required are so great that the justification must be found in indirect benefits to the society which we cannot evaluate in scientific terms. However, we know no other opportunity at this time so unique in the experience of man, nor with more power to challenge our fundamental ideas about the universe in which we live and about our own uniqueness as human beings.

Indirect benefits from space endeavors.—A number of indirect benefits from the space program result from efforts to solve scientific and technological problems of unprecedented difficulty which result from the acceptance of a set of challenging goals. Furthermore, the nature of the technical effort is such as to demand close collaboration and work of the very highest

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quality from our industrial, scientific and government communities. The resulting benefits may not be measurable in dollars and cents terms, and it may not even be true that the space program is unique in providing them, but we believe that they have made important contributions to our national stature and well being.

Technological excellence.—Even more than the military missile programs that preceded it, the space program has placed demands on U.S. industry for engineering and production at quality levels not previously attainable. To meet the requirements for extremely sophisticated space systems with very narrow design tolerances which must function correctly in every detail on first test, new methods of engineering and production management, new methods for component testing and quality control, and most importantly new attitudes towards workmanship have been introduced. While many of these procedures may be unduly costly for immediate introduction into general industrial practice at this time, there seems very little doubt that these new approaches to industrial engineering and production will have increasing impact on the quality of industrial output, and thus ultimately on productivity.

It is sometimes stated that the specific technological developments derived from the space program are not very relevant to the immediate needs of the private industrial sector. This is very probably true in the main. Even so, many people, notably including many European industrialists, are convinced that the industrial sophistication generated by the military and space programs has given the United States an important competitive advantage in all technological fields. The gap in the "technological balance of payments" which operates to the disadvantage of the nations to whom we are exporting sophisticated technology is, in fact, often ascribed to the influence of the U.S. space programs and military development programs.

As another example, the aerospace industry is often cited in the United States as a potential resource for innovative development in such fields as transportation, because of its demonstrated flexible and imaginative attitude toward extremely complex engineering systems.

National self-confidence.—The doubts concerning the stature of American science and technology which were raised in the minds of many U.S. citizens by the USSR Sputnik have apparently been assuaged by the success of the U.S. space program. They have been replaced by a conviction that the United States can now develop whatever capabilities in space might be needed. In addition, there is increased public confidence that the United States can mobilize its scientific and technical resources to attack virtually any national problem amenable to technical solution. This increased national self-confidence is a matter of great consequence. Our society is increasingly based upon technology. And many of the most important problems we face will require for solution the combined efforts of a number of people and organizations, some in the private sector and some not. The Panels believe that the demonstration of the success of the U.S. space program as conducted by a partnership of government and industry has contributed and will continue to contribute importantly to the confidence of the public that similar partnerships can successfully attack other pressing public problems. In building this national self-confidence and through it, making possible more effective attacks on urgent social problems by the government in the public interest, the space program is making an important contribution.

A peaceful space posture and international cooperation.—The effect of the space program on the attitudes of other nations toward the U.S. is not easily assessed with any degree of assurance. As suggested earlier, the importance of achieving short time leads over the principal competitor in space exploration may well be transitory. Surveys concerning "man on the street" attitudes toward the relative scientific and technical strength of the U.S. and the USSR over a period of several years of alternate space spectaculars are not very thorough or convincing. The Panels are inclined to attribute much more significance to the attitude of Americans toward their own society, as it is influenced by our space posture.

However, two factors may be of considerable importance to the United States. First, the U.S. space program, in contrast to that of the Soviet Union, is predominantly peaceful in character, operated outside of the Department of Defense, and conducted with full public disclosure. The predominantly civilian character of the overall U.S. space program is more appropriate to the international posture which the United States traditionally wishes to present than would be a scaled down effort in which the military program might be the dominant part.

Second, the space program provides a key opportunity for U.S. efforts to find a basis for peaceful relations based on a more open and less distrustful Soviet society, possibly culminating in direct cooperation on a significant scale. There are a number of encouraging signs that the space program plays a role here, quite apart from the substantial amount of scientific contact between the U.S. and USSR that the space competition generates. The open reporting of our successes and failures as they occur places the more secretive Soviet program in such a contrasting light that it may have contributed to the increasing willingness of the USSR to announce launch dates in advance and provide information on the inflight progress of their missions. Soviet pride in their own space achievements is very great, and provides a motive for greater disclosure and continued contact with space activities in the West. The interests of the two nations in space exploration may be served in the future by a degree of cooperation which might contribute importantly to improvement in relations through the development of mutual trust in an area relatively free from political complications.

Level of effort in space exploration.—In the area of space exploration, where the primary benefits are largely subjective, the consideration of benefits provides better guidance for the choice of space objectives than on the level of effort. The level of effort will necessarily depend on an evaluation of the public concensus supporting exploration and its scientific goals, together with more practical considerations of an economic, political and perhaps military nature. The effect of radical changes, up or down, in the total level of effort on future industrial capability and on engineering and scientific manpower, as well as local economic impact, will always require assessment. And the availability of resources to the Federal Government for investment in space projects will not always follow a smooth course. This mix of factors cannot be evaluated by these Panels nor can we predict the future variations in their relative importance.

It may be useful to note, however, that some qualitative constraints on level of effort are inherently related to the indirect benefits which we believe do flow from the space program as presently conducted. The discipline of a sense of urgency and of strong pressure against the technological state of the art is important to the technical vitality of the program. The element of technical sophistication accompanied by stringent quality control is an essential feature on the engineering side. Scientifically, the missions must be directed at the questions of the greatest scientific consequence and pursued in a manner reflecting the highest scientific standards. Goals for the space program which demand excellence in conception and in execution are essential to the realization of the full benefits of the effort. The optimum level of effort lies between that which is so low as to remove the discipline of rapid progress or so high as to remove the necessity for ingenuity and for pressing the technological state of the art.

The nation can choose any one of several different levels of space effort. The program can be extremely ambitious and press rapidly forward with manned exploration of the planets, or can be less expensive and emphasize a larger proportion of unmanned missions in near earth space; the choice must depend on evaluation of the direct and indirect benefits such as those discussed above. But whatever choice of goals may be made, the pace of the effort must preserve the elements of technological and managerial excellence without which the benefits are not realized. At too low a level of effort the program might lapse into a routine and repetitious series of demonstrations and collections of data of marginal value. There is therefore a threshold for the level of investment in any given set of space goals below which a proportionate return is in doubt.

Section III. Conclusions and Recommendations

The problem of new major space goals.—For the first decade of the U.S. space program the major goal has been to develop as soon as possible a capability in depth to carry out operations in space for a variety of the purposes discussed in the previous section. To give this objective focus and a sense of urgency, especially in view of the initial successful demonstration of this capability by the Soviet Union, a single major program objective, project Apollo, was selected and given a target date for successful completion. There is little question that the Apollo mission has played a focal role in the U.S. space program for several years. However, the incisive nature of the Apollo goal during this period has been enhanced by several special circumstances: its announcement shortly after the feasibility of manned space flight had been demonstrated by the USSR; the need for the United States to undertake a manned space flight program which would not only be challenging in itself but also of sufficient magnitude and pioneering daring to display clearly to the world at large the technological and industrial prowess of the American economy; and its direct usefulness for expanding U.S. space capabilities because the remainder of the space program at its inception was at a relatively low level in both magnitude and technical sophistication.

In considering the U.S. space goals for the decade of the 1970's, the Panels are aware that the selection now of a single dominating project for NASA has a number of advantages. Such a project (for example, a Manned Mars flyby in 1975 or a manned orbiter or lander on Mars in the late 1970's) has great potential for giving technology developments the discipline of relevance, and for focusing national attention on an easily understandable and supremely challenging goal, progress toward which is easily assessed by ourselves and by other nations.

The Panels, however, are also aware that the situation has changed radically during the last 8 years. Our space program has been very successful in developing a spectrum of national capabilities for operations in space. A large and well disciplined military use of space technology in DOD, the operational weather satellite programs in ESSA and NASA, a successful unmanned space science program and the expected success of Apollo itself are testimony to this fact. Thus we are starting out, in 1967, with a well rounded space program involving several agencies, and have even begun to see private investments in space operations. Our question in 1967 is not so much "what major endeavor will best provide a basis for expanding our space technology and operational capability?" but "what are the most advantageous ways to exploit this great capability for the achievement of the national purposes addressed in the previous section?"

The Panels recognize that the most challenging ultimate objective for space exploration is the exploration by man of the nearby planets. But we do not yet know enough either about the relative attractiveness of the various planets and the Moon as subjects for exploration or about the feasibility of a manned voyage of two years duration to permit a rational choice of a major new mission and the assignment of a time frame for its attainment. At this critical point in our program, when new results and achievements are coming in very rapidly, we feel the U.S. space program should be planned with a substantial margin of flexibility in objectives, so that resources can be rapidly reprogrammed to exploit new scientific findings and major changes in capabilities to operate in space.

Therefore, the Panels favor a balanced program based on the expectation of eventual manned planetary exploration, integrating manned and unmanned efforts to arrive at the following five major objectives:

1. A limited but important extension of Apollo in order to exploit our anticipated capability to explore the Moon.
2. A strongly upgraded program of early unmanned exploration of the nearby planets on a scale of time and effort consistent with the requirements for planning future manned expeditions.
3. A program of technology development and of qualification of man for long duration space flight in anticipation of manned planetary exploration.
4. The vigorous exploitation (by all appropriate agencies of Government) of space applications for national security and the social and economic well-being of the Nation.
5. The exploitation of our capability to carry out complex technical operations in near Earth orbit (and on the Moon) for the advance of science, particularly astronomy.

Lunar exploration.—Introduction.—A recent evaluation of progress in the Apollo program by the Space Technology Panel of the President's Science Advisory Committee satisfies us that the prospects of success for Apollo are good. It is likely that the first successful manned lunar landing and return will be completed before the end of 1969. The capability of the present Apollo system for exploiting the presence of man on the lunar surface for scientific purposes is, however, limited. The system lacks not only the tools and equipment needed for extensive scientific exploration but also the ability to move on the surface of the Moon and the ability to stay on the surface for an extended length of time. Of course, it is desirable to preserve as much flexibility as possible so that the purposes of subsequent lunar missions may be adapted to the discoveries made in the first one or two landings. It already appears clear, however, that the repetition of Apollo flights for more than two or three missions will be unjustifiable in terms of anticipated scientific return without the modification of the system

to provide for additional mobility on the Moon's surface and the capacity to remain on the surface for a longer period of time.

The degree of uniformity of the flat lunar areas seen so far suggests that the principal advantage manned exploration would have over an unmanned mission would be the ability to seek out the rare but especially interesting lunar features. Examples might include young craters or rills that would permit inspection of material characteristic of the subsurface layers, or features which might support the venting of gaseous material through the surface. It will certainly be desirable to examine the rough lunar features whose inclinations make them unsuitable landing sites. If such features are to be accessible to man, without a delay of several years, one must proceed soon to develop both the means for extended visits to the moon *and* the mobility to reach terrain unsuitable as a landing site with sufficient supporting equipment to carry out the various explorations and scientific tasks which may then seem appropriate.

While actual experience on the lunar surface will be needed to determine the precise requirements, we anticipate that the only system that will be able to satisfy the general objective in the 1970–72 period is an adaptation of the Apollo system itself. One possible adaptation would be a system which would utilize the payloads of two independently launched Saturn V rockets, one, the basic Apollo configuration, and one in which the manned Lunar Module is replaced by an unmanned module capable of landing about 7,000 lbs. of logistic support on the lunar surface. In this system, the unmanned module could provide additional scientific experimental payload, shelter for a period of 7–14 days and increased mobility in the form of a lunar roving vehicle allowing the crew to explore an area of several miles radius. This is consistent with our best estimate of what may be required. We therefore recommend that such an extension of our exploration capability be provided, to be available for missions following the first two or three basic Apollo lunar landings.

If the first successful Apollo mission does occur in early 1969, the Apollo systems now scheduled for later flights will become available for alternative uses. Because there is little time in which to meet the above recommendation for extended lunar exploration and assuming that the recommended modifications to provide the unmanned logistics, mobility, and shelter module can be made, we urge that the lunar exploration program be given priority over the other possible uses of Apollo hardware such as those proposed in the Apollo Applications Program. (See pp. 35–37 for a discussion of how launch vehicle production rates relate to this.)

We are also convinced that a carefully cordinated program of unmanned lunar exploration should be continued in order to take best advantage of the very costly and relatively infrequent manned expeditions. The unmanned program should obtain information that will assist in the selection of landing sites most suitable for scientific exploration as well as crew safety. In addition, an unmanned vehicle capable of landing on and examining the regions nearer the poles (Apollo can land on only a narrow equatorial band) will tell us whether the polar regions are sufficiently interesting to warrant future development of a capability to place men anywhere on the lunar surface.

A final comment should be made about the possibility of using the moon's surface for astronomy. In general, we expect that the large majority of new endeavors in space astronomy will be more advantageously and economically accomplished by instruments in earth orbit. The surface of the moon may, however, present certain unique opportunities which should be exploited if and when the capability to do so is available from the programs designed for lunar exploration. Examples are the use of the lunar horizon as a reference for solar and planetary observations, the employment of the lunar surface as a platform for long base line interferometry, and possibly taking advantage of the low background noise environment on the back side of the moon for astronomical measurements in the optical and radar frequency bands. None of these necessarily requires a manned lunar base and at this early time we do not believe that a decision to establish a lunar base could rationally be made.

> *Recommendations.—In the period after the initial two Apollo lunar landings we recommend that a sustained program of lunar exploration proceed as follows:*
>
> *a. Continue manned expeditions at the rate of between one and two per year.*
>
> *b. Provide each manned expedition with logistics support as recommended above, shifting over to any alternative system (for example, one based on a direct trip to the moon without rendezvous) when the economics clearly favor it.*
>
> *c. Provide supplemental unmanned lunar exploration systems. One important component of this program during the early 1970's will be unmanned spacecraft capable of landing significant scientific payloads anywhere on the moon, particularly the lunar poles.*
>
> *d. Since we expect that it may prove valuable to send manned expeditions to parts of the moon not accessible to the present Apollo system (e.g., the polar regions), planning should be initiated to enable the achievement of this capability in the 1975–80 period.*

The average launch rate recommended above is intended to be consistent with a lunar exploration program which is deliberate and systematic enough to allow each step to benefit, scientifically and technologically, from the consolidated results of prior projects. We realize that this may stretch out the period of time required to accomplish the desired tasks by occasionally delaying the development of some spacecraft or instrument until new information makes the design of the correct one possible. Our recommendation should therefore be viewed as a provisional guideline suggested

to us by current knowledge, and certainly subject to future modification based on inevitable changes in both knowledge and technology.

Planetary exploration.—Introduction.—There is widespread agreement within both PSAC and the NAS Space Science Board that, in addition to space programs of military and economic benefit, the exploration of the planets and space astronomy should be primary objectives around which the U.S. space program should be oriented during the post-Apollo period. These objectives offer a supreme challenge because their accomplishment may lead to answers to scientific questions of great human significance concerning the origin and evolution of life, of the solar system and of the universe. An evolutionary program to exploit the opportunities in space astronomy is discussed on pages 26–30. The specific steps involved in moving towards planetary exploration are less clear, especially regarding the proper relationship between the manned and unmanned programs.

We believe that planetary exploration should set the pace for the post-Apollo space program, in the sense that the total budget for programs which relate to this objective should constitute the largest part of the budget for NASA. We also believe that the expectation of eventual manned planetary exploration will both stimulate and direct the major technological developments of the post-Apollo period. It is premature to establish any fixed timetable or even to be certain which planet will be the priority objective for manned exploration. Rather, the Panels have attempted to define an orderly approach that fills in gaps in our present understanding and provides a basis for making concrete decisions as soon as adequate understanding is available on how and when man can be useful in planetary exploration.

The Panels also wish to re-emphasize that opportunities are great for obtaining detailed information about planetary surfaces and atmospheres from earth-based optical and radar observations and from earth-orbital optical observations. A balanced planetary program necessarily should reflect an assessment of the relative significance of such observations, and their cost, from the point of view of how they contribute to increased scientific return from subsequent missions. Fundamentally, all space flights should be aimed at the return of data not obtainable from the Earth.

Coordination of manned and unmanned activities.—The most serious difficulty confronting the Panels in attempting to delineate the specific steps the U.S. should follow to emphasize planetary exploration in the 1970's has been the absence of integrated NASA planning in this area. Rather, the Panels have been presented with two distinct and apparently independent plans for planetary exploration. On the one hand, there is the Voyager program, centered around unmanned Saturn V launched missions to Mars in 1973 and 1975, with the intent to soft-land Surveyor-type spacecraft capable of returning data from an automated payload of scientific experiments landed on the surface of the planet. On the other hand, the Panels were presented with a detailed plan for a manned mission to fly to the immediate vicinity of Mars and return (Mars flyby), possibly as early as 1975, which, if successful, could collect a massive amount of information about Mars, perhaps including the return of a small sample of Martian surface material. In these latter presentations it was suggested that a single Mars flyby mission of this type might return a greater amount of useful information than is likely to be returned by the entire proposed program of Voyager missions to Mars in the 1970's. In the separate presentations there was, however, little indication of joint studies to develop agreed comparisons of the two types of missions or to develop a possible mixed strategy in which manned and unmanned missions were both utilized.

The manned Mars flyby proposal, among its other weaknesses, does not appear to utilize man in a unique role. In addition, one must recognize the great uncertainty necessarily associated with schedule and cost estimates of the flyby mission in the absence of any experience relevant to the reliability of equipment and the capabilities of men on interplanetary missions of durations 50 times longer than the Apollo mission.

Thus it appears to us that NASA must address itself more fully to the question, "What is the optimum mix of manned and unmanned components for planetary exploration?" Out of such a study presumably would come a more flexible Voyager concept compatible with possible manned ventures, and also a specific identification of man's unique, or most effective, role in planetary exploration.

The role of unmanned investigations of the planets.—There is an additional weakness common to both existing proposals for planetary exploration—the implication that sufficient knowledge exists at present to warrant the commitment of large resources for the exploration of a single planet, Mars, at the expense of more balanced efforts for the other planets. The pictures and other data from the Mariner IV flyby of Mars in 1965 depicted a more moonlike and less earthlike planet than had been generally expected, and dramatically demonstrated the scientific value of early pioneering flights of low relative cost and modest capability. Even before the Mariner results, however, the presence of water had been confirmed in the atmosphere of Venus, generating a renewed interest in that planet as a possible locale of organic molecules, if not primitive life-forms. The Panels thus feel that maximum immediate priority should be placed on early unmanned flights to Venus and Mars of intermediate capability in order to determine which, if either, should be the focus of a much larger definitive exploration during the 1970's. Favorable launch opportunities for these planetary flights occur relatively infrequently, for example, only about every 18 months for Venus and about every 24 months for Mars. In this regard, the 1970 Venus launch opportunity should be given particular consideration for an unmanned mission to the planet with a probe which will measure atmospheric properties (especially temperature and pressure and, if feasible, molecular constitutents) down to the surface of Venus. Such a mission in 1970 could return definitive information about that planet in time to affect the main thrust

of the Voyager Project or a manned planetary mission in the late 1970's. It would seem difficult to expect the direction of such programs, particularly Voyager, to remain fluid until 1972, the time presently contemplated by NASA for such an unmanned Venus mission.

As a specific problem, the Panels believe that more attention must be given to the possible utility of unmanned systems to obtain and return samples of the surface material of Mars and Venus. These systems will doubtless be expensive but they may still be much less expensive than manned missions and they may take a smaller development time. In any case, the important need is for a full and thoughtful comparison of manned and unmanned systems to accomplish the various objectives.

Although of less interest from the point of view of manned exploration, we would place almost as high a priority on new pioneering missions to Mercury and Jupiter. Technically, such flights are feasible as early as 1970 and could lead to results even more unexpected than did Mariner IV, because existing ground-based information is even less definitive for the more distant planets. It is important to note that, while opportunities for Jupiter occur almost yearly and a launch vehicle with the capabilities of the Saturn V is required in any case, a mission to Mercury using an Atlas-Centaur launch vehicle, in which the spacecraft would also fly by the planet Venus before reaching Mercury (a Venus "swingby"), is possible in 1970 and 1973, but not again until the 1980's.

The Panels also wish to emphasize that, regardless of the detailed manned-unmanned mix, and of the eventual priorities of Mars versus Venus, a Surveyor-type, soft-landed vehicle for Mars will be required. A start must be made on development of components and systems in fiscal year 1968, particularly related to the sterilization problem, if this technology is to be available by 1973.

Role of man in planetary exploration.—At present, the most effective uses of man in planetary exploration have not been identified. For example, one can envision a manned Mars (or Venus) orbiter, in which the crew orbits around the planet but does not land, while controlling from orbit a number of unmanned probes and soft-landed mobile vehicles in real time. One of these unmanned probes might scoop up a small sample of Martian soil, encapsulate the sample, and then launch the capsule toward a rendezvous with the mother craft in orbit. Although in principle many of these functions could be carried out by means of a fully automated, preprogramed system, the complexity of such a system and the need for redundancy might be so great that the crew may more than pay its own way. Compared to a direct manned landing, a manned orbiting expedition has the great advantage of requiring a substantially lower initial weight in earth orbit. In addition, it permits us to concentrate on solving the sterilization and back-contamination problems with unmanned subsystems before attempting the more difficult problem of a manned landing.

These remarks should make it clear that our serious reservations about a manned Mars flyby in 1975 do not stem from any doubts about the eventual utility of man in planetary exploration. Rather, we remain unconvinced that a manned Mars flyby is the most effective use of man, as compared, for example with a manned Mars orbital mission and also uncertain that estimated costs and time scales are meaningful at this early stage in our knowledge.

In addition to these questions we are concerned about the proposed use of Apollo technology necessarily implied by a Mars mission planned for 1975. Much of this technology was necessarily frozen into 1961–63 state of the art by the tight time schedule of the Apollo program. By adopting a somewhat more leisurely schedule for a manned planetary flight, perhaps aimed at a mission late in the decade or in the 1980's, we might buy the time required for a vigorous development of new and more efficient onboard power supply systems and other critical subsystems, thus permitting an orderly increase in total space capability. Most importantly, we would then have the necessary time to design man into the system rather than to have him be primarily a passenger.

Recommendations.—a. We recommend that particular consideration be given to providing during the 1970 launch opportunity an unmanned planetary mission capable of probing the atmosphere of Venus, as part of an orderly U.S. program of planetary exploration.

b. We recommend an expanded commitment to the Voyager planetary lander program, pointing toward a soft landing of a Surveyor-type module on Mars in 1973 but with provision for the possibility that a similar mission to Venus may also receive a high priority for the early 1970's. We recommend that particularly vigorous attention be given to the long development times in designing and preparing components and subsystems necessary for a 1973 Mars soft landing, especially those which must meet rigorous sterilization requirements.

c. We recommend that during the 1970's unmanned spacecraft be sent to Jupiter and Mercury, accessible planets of great scientific interest. An opportunity to flyby Mercury as an extension of the recommended 1970 Venus mission should be considered seriously if it does not appreciably decrease the probability of success of the Venus probe.

d. We recommend that NASA conduct as soon as possible a carefully integrated study of the relative effectiveness of man in planetary flyby and orbiter missions to Mars and Venus, considering manned and unmanned modes in all relevant combinations. One object of this study must be a clear identification of how the various Voyager missions proposed for the time period 1975–79 would be related to manned planetary missions which are felt by NASA to warrant serious consideration. A further object should be the determination of the appropriate ground-based and earth-orbital observations required to insure the maximum effectiveness of direct exploratory ventures projected for the 1970's. The results of this study should be available by the summer of 1967.

Biomedical studies and the qualification of man for long space missions.—Introduction.—We may consider man as a participant in space missions from four aspects: (*a*) in gaining basic biomedical information about himself, and from observations on animals under "overstress" conditions and other circumstances allowing extrapolations useful for solving problems of using man in space (additionally, he could pursue studies of simple cellular systems and of human and animal tissues pertinent to man's qualification for long flights); (*b*) in evaluation of the role and reliability of man as an observer of terrestrial and astronomical events, and of events within the spacecraft, and as an operator of complex instruments to acquire data on such events; (*c*) in assessment of his abilities as an engineer charged with the operation of spacecraft systems and the diagnosis and therapy of spacecraft problems; (*d*) in evaluation of his abilities to perform as a member of a highly integrated team, and his capacity to sustain effective interpersonal relations under the stress of a prolonged flight. Three critical questions could be posed, and hopefully answered, by manned flight in earth orbit: Can man survive in the space environment for several years? Beyond survival, will he continue to perform effectively, and will the fundamental knowledge gained about him and the technological effort involved in assuring his effectiveness attest to the feasibility of manned interplanetary flight? What concepts of components and systems design will prove most useful in enhancing man's effectiveness and, equally important, to increase the overall reliability of the systems?

Man as a living organism has evolved over extremely long periods of exposure to the earth's gravity and it is unreasonable to assume that his sudden removal from this influence will be without significant and subtle effects on his capabilities. Despite such possibilities, there appear to be sound reasons to view his participation in space flight as vital in areas where complex and multiple judgments are required, particularly if mission reliability could be enhanced by utilizing man to exercise an ad hoc planning and decision-making role. The first substantive step towards such a goal should be critical evaluation of his capabilities in earth orbit.

Qualification of man for flights prolonged substantially beyond the current maximum of 14 days will require special consideration of his ability to perform for indefinitely long times at a high level, both mentally and physically. While no definite period of exposure to the space environment can now be set as a criterion for qualification of man for flights such as those to a nearby planet covering a round trip of perhaps 700 days, it seems likely that a test epoch of 100 to 200 days in earth orbit would reveal most or all physiological and psychological disorders likely to be deleterious to mission performance.

Available and needed biomedical information.—A wide gamut of fundamental information in basic biology and mammalian physiology should be acquired concurrently with observations on man. Studies in cellular biology will provide unique information on the effects of prolonged exposure in space in simple living systems. Observations in animals can be anticipated to provide more detailed and comprehensive information on central nervous, cardiovascular, and metabolic functions than would be feasible from studies in man. For these reasons, it is recommended that NASA proceed vigorously with such investigations, both in biosatellite flight programs and as an aspect of extended orbital manned flight in vehicles suited to animal management.

Gemini and Apollo missions are too short to allow reliable extrapolation about such abilities for protracted periods. Data so far gathered on man in Mercury and Gemini flights cover the period of transition in physiological systems in their adaptation to weightlessness and other space environments. These data have been comprehensive only in certain aspects of cardiac and respiratory functions and even here they are of a qualitative nature. Fragmentary and entirely inadequate information has been obtained on central nervous, metabolic, and endocrine systems.

Inadequacies in bioinstrumentation have impeded collection of information in such areas as metabolic rates in basal and active states in space flight, and collection of blood, urine, and feces for postflight analysis. Although approximate mean metabolic rates have been derived from the measurement of carbon dioxide absorption in the cabin life support system, nothing is known of actual metabolic rates during extravehicular activity (EVA), where rapid breathing during exercise has consistently occurred. No detailed evaluations have been possible of patterns of muscular activity and motor coordination in skilled movements of the unrestrained individual in spaceflight. Although the evidence suggests that brief, heavy workloads can be met adequately, the findings are equally suggestive of impaired capability in prolonged effort, both during and after flight. Very rapid heart rates during physical effort in EVA, even to the point of exhaustion, require evaluation of factors in space suit design, as well as assessement of maximum tolerable workloads. There is a requirement for detailed analysis of cyclic aspects of sleep and wakefulness and optimal work-rest cycles, and of central nervous activity accompanying focused attention during task performance, with assessment of attention span and the onset of fatigue and drowsiness.

An orderly investigation of man's qualification for prolonged flight must take account of variations between subjects and varying conditions in different flights. The study of subjects to be flown for adequate biomedical baselines should therefore continue until appropriate consistency can be established. Adequate pre- and post-flight baselines have been substantially lacking in earlier missions.

We recommend that R. & D. efforts to provide improved bioinstrumentation for man (and test animals as required) be stepped up, and that NASA develop more effective plans both for providing adequate pre- and post-flight baseline data and for insuring that the flights available for furthering these studies take full advantage of the biomedical technology now available.

Choice of spacecraft.—It would appear that the only realistic avenue for acquisition of much of the importantly needed biomedical data lies in the use of earth-orbital stations offering life support in work areas substantially larger than available in the Gemini spacecraft or in the Apollo Command and Lunar Modules. Minor modifications to these spacecraft will not make them adequate for the full spectrum of physiological and psychological manipulations essential for man's long-term qualification.

NASA has suggested development of the empty liquid hydrogen fuel tank of the upper, or final propulsive stage of the Uprated Saturn I launch vehicle (following exhaustion of the fuel in achieving orbit) for use as a test space during extended earth orbital flights. Access to the hydrogen fuel tank would be gained from the Apollo Command Module by a hatchway through a specially constructed airlock which would also provide the capability of docking the Command Module and other major assemblies with the spent propulsion stage. The available volume in the empty hydrogen tank would be approximately 10,000 cubic feet. The combined spent stage and airlock are commonly referred to as the "orbital workshop."

Since no equipment, partitions or other impedimenta can be installed in the tank prior to launch, astronauts would be required to take with them all apparatus and living needs. It would be necessary for the astronauts to build floors, sleeping areas, and other essential needs for habitability. The prime objectives of such missions would be biomedical, with evaluation of man's abilities in repair and maintenance. Later NASA plans include consideration of orbiting an SIVB stage already furnished as a laboratory.

In the light of recent experience in EVA, some doubts arise about man's ability to carry out extensive construction efforts in space. The requirement that man actually construct his laboratories in space in these initial applications may constitute a serious impediment to their development, despite the advantages of a large available volume. Given these uncertainties, it is essential that opportunities should not be lost to gather detailed biomedical data from carefully conceived experiments accompanying the construction procedures. Without such data, our ability to extrapolate further in man's qualification would not be materially assisted. For these reasons, the opportunity for a detailed and more gradual approach to increasing task requirements may lie in the maximum utilization of the Department of Defense Manned Orbiting Laboratory (MOL), where fully developed laboratory and living areas would be developed prior to launch. Available volumes would be greater than in the Apollo spacecraft, although substantially smaller than the hydrogen tank of the Uprated Saturn I second stage, with the opportunity to test man for periods of 30 days or longer in a shirt-sleeve environment. Utility of this vehicle for biomedical qualification depends to some degree on the date at which it might be available for use in detailed biomedical testing. We expect the MOL program will be providing basic experience and biomedical data on 30-day flights in 1969–71. Because of the rigorous demands that detailed attention to experimental procedures will place on man's ability to perform and the availability of an adequate pressurized living and working space, MOL could provide useful and timely data in addition to that obtained by NASA, which would be pertinent to qualifying man for planetary flight. This view requires, however, that the Air Force expand their planned program for biomedical measurements and qualification tests of the astronauts.

It may be desirable for NASA to acquire MOL vehicles for its use in biomedical qualification, particularly if delivery by 1970 or 1971 can be arranged. This will be the more feasible if NASA were to make a decision soon to acquire MOL vehicles and start the initial funding so that increased production could be arranged in a timely manner.

Second generation laboratory environments.—The next significant step toward the qualification of man beyond that which can be provided by minor adaptations of MOL, or by the Apollo Applications Program, will require either a new spacecraft development or major redesign and large additions to either the Apollo or the MOL basic components. Using Apollo as a base, one might use adaptations of the Command Module, but would very likely discard the Lunar Module and the Service Module and develop a new laboratory module. If designed for launch by the Uprated Saturn I vehicle, a rendezvous of two of these laboratories would probably be necessary to provide the desired working space and crew size. Starting with MOL components, one might consider using the basic Gemini B, two MOL laboratory modules joined together and modified for docking, and a rendezvous of two of these complexes to get the necessary space and crew size. As a third alternative, a more effective use of funds might result from development of an entirely new laboratory complex for launch on a Saturn V.

Before a major effort is directed to a new form of large laboratory complex, four questions should be answered:

a. Is an artificial gravity necessary, and if so, by what means should it be secured?

b. What atmosphere should be provided, and what diluent gases should be used in a mixed gas system?

c. What are the requirements for "comfortable living," particularly in relation to feeding and hygiene?

d. What are the optimal procedures for man's utilization in space as an observer, as a mechanic, and as a decisionmaker?

Recommendations.—In summary, we recommend that:

a. Physiological and psychological studies of man for extended periods in space should be associated with experiments under continuous medical observation, and under conditions which permit these experiments to be useful in predicting performance in interplanetary flight. Appropriate working environments and bioinstrumentation must be provided.

b. The proposed orbital workshop experiment of the Apollo Applications Program utilizing the spent second stage of the Uprated Saturn I vehicle should proceed. The launch vehicle and spacecraft for this experiment are already on order, and the opportunity for 28- to 56-day flights in 1968 should be taken.

c. Before substantial funds are committed to the AAP plan to modify Apollo hardware or to utilize the orbital workshops for extended periods, a careful study should be made of the suitability, cost and availability of Titan III/MOL systems for biomedical studies of man for periods up to 60 days. NASA should also investigate whether delivery of these components could be speeded without interference with the MOL program if additional funds were contributed to MOL in the formative years of the program.

d. Arrangements should be developed between NASA and the USAF to use the MOL program as an important source of data on the capabilities of man for space missions lasting 14 to 30 days, in addition to experience to be gained in early Apollo Applications missions. Biomedical investigations currently planned by the USAF in these flights are strictly oriented towards 30-day flight requirements and would need to be substantially expanded to take their place in progressive qualification of man for interplanetary flight. The USAF is therefore urged to take greater advantage of physiological and psychological tests in MOL that would be framed to aid in evaluation of man for planetary flight.

e. The next significant step in biomedical studies will involve extended duration flights of 100 days or more, and will require major redesign of MOL components, or major new developments if based on Apollo hardware. The determination of the most effective and economical approach requires a detailed study in which MOL components are explicitly considered as a possible alternative. NASA should initiate such a study as soon as possible.

f. NASA should proceed vigorously with basic bioscience programs in biosatellites and in prolonged manned flights with vehicles suited to care of animals and simple living forms. In addition to its fundamental value, this information could be important to our understanding and solution of problems of manned flight.

Space science in earth orbit.—Introduction.—Satellites in earth orbit provide freedom from the effects of gravity, exposure to a near perfect vacuum, and escape from the blanketing effects of the earth's atmosphere. Since their orbital motion can be observed from the ground with high precision,

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satellites are capable of yielding new data on the earth's atmospheric density and the terrestrial mass distribution. These orbits also provide a view of a large area of the earth's surface from a single orbiting station, in addition to permitting the introduction of measuring instruments into the earth's outer atmosphere and the surrounding interplanetary medium. Instrumented satellites have already permitted great advances in many fields of science and will continue to do so in the future.

Space science in earth orbit may be divided into three categories: (*a*) laboratory experiments requiring zero-g; (*b*) observational programs directed toward the earth and its environment; and (*c*) programs directed toward astronomical observations of outer space extending from the solar system to the deepest reaches of the universe. The first of these has technological and biological importance; the second is important in providing the capability for communications, weather prediction services and other applications; the last is the focus of our recommendations for the major pure science component of our space program. We will discuss each in turn.

Experiments requiring the space environment.—For certain experiments in fundamental physics—especially in relativistic mechanics—satellites may provide unique opportunities. In engineering there are problems of fluid flow at zero-g which are important in space technology and should be the subject of additional basic research. Fundamental problems in developmental and cellular biology may be usefully attacked under the zero-g environmental conditions. The research in mammalian physiology required to qualify man for long-term flight moreover, contains many elements of fundamental biological interest (see pp. 20–25). These are samples of space research of a nonobservational character, in which the conduct of the experiment in orbit is desirable only because of the environmental conditions there. Thus, in considering these experiments as candidates for spacecraft or orbiting laboratories, the relative cost and practicability of artificially producing the required environmental conditions on earth (for example high vacuum, altered g) provide the needed criteria for decision. A number of such projects do have the necessary merit and cannot be performed on earth at lower cost; these should be supported. But we do not feel that (with the obvious exception of the human physiology program) their number or scale justifies a space station for this purpose alone, even though they might be performed in one. Thus the impact of these requirements on the long range space program is small and needs no further discussion.

Observations and exploration of the earth, the sun and the interplanetary medium.—Research on the properties of the earth's atmosphere, near-earth space, the interplanetary medium, the shape and mass distribution of the earth's interior, and observations of the sun have been very rewarding in purely scientific terms and have lent indispensible support to applications of economic and social benefit both in space and on earth. They

merit continued strong support. Rocket probes and space vehicles, used with carefully planned support from ground-based observations and from theory, are essential for such work. The progress already made in these fields is one of the spectacular achievements of the space program, and has caused the evolution of these scientific fields from the exploratory stage to the point where detailed understanding of the very complex phenomenology is possible. Applications in meteorology, communications, and other activities dependent on understanding the earth's environment have already resulted from this research, and it appears likely that much greater opportunities for useful applications lie in the future (see pp. 32–35).

The level of effort of the current NASA program (about $100 million in 1967) appears reasonable in the light of the current status of the applications program. Growth of the effort will be needed as the demands of expanded applications in the environmental sciences increase.

Space research directed toward the earth and its environment is now characterized by participation of many scientific disciplines and hence many investigators; by the need for multiple coverage in space and time; by the interlocked design of space-borne and earth-bound sensors and transmitters; and by the acquisition of large amounts of data which are preselected by the special purpose design of the observing instrumentation. All of these factors tend to make almost inapplicable to this field the savings which can otherwise be made in payload cost per unit weight in orbit by going to large boosters and large payloads. Further, this appears to be one of the last research areas to which the use of instrumentation operated by men in orbit will be found to be cost effective.

On the other hand these factors also make inapplicable the savings which result from limiting the number of missions to a very few; in these areas of science spatial and temporal variability and the complex nature of mutual environmental influences dominate the scientific problems and lead to a desire for many special purpose missions.

We therefore recommend that investments by the Federal Government in research on the near-earth environment—meterology, aeronomy, ionospheric physics, geophysics, particles and fields in the interplanetary medium, and the physics of the sun—should continue to grow in proportion to the anticipated size of the applications programs and predictions and warning services which depend for their cost effectiveness on progress in these sciences. We urge special attention be given to the need for a large number of relatively small and flexibly assigned payloads, and we regard the evolution of large general purpose earth orbital research facilities for this field as unlikely to be of greatest value. We suggest that at least part of this expansion in space-based environmental research should take place in the agencies responsible for applications programs (such as DOD, ESSA, and perhaps Interior). NASA's responsibilities will, however, continue to be required in support of the basic research and in the development of new vehicles and observing techniques. We anticipate that by the mid-1970's the total Federal support in this area should be double the level of 1968, but that NASA's contribution will grow at a less rapid rate than this as other agencies become more active. On pages 34–35 we make recommendations concerning research and development on the applications programs themselves; finally we recommend that in the comparison of manned versus unmanned modes of carrying out research in this field the criterion of relative total cost effectiveness be applied to the extent possible. We anticipate that for research on the near-earth physical environment the optimum program will prove to be almost entirely unmanned.

During 1966, NASA has been engaged in planning for a series of man-supported scientific missions in near earth orbit as part of the Apollo Applications Program. The first of these missions is intended to provide a manned solar observatory, with its experiments based on those which were under development for the proposed unmanned Advanced Orbiting Solar Observatory (AOSO). The Panels reviewed the plans for this mission, the instrument package for which is called ATM (Apollo Telescope Mount), at several stages during the rapidly evolving concepts of spacecraft configuration and instrument operation. (Appendix C is a discussion of the ATM as it was envisioned on September 29, 1966.) It was clear from this review that the ATM concept illustrates both the opportunities and difficulties associated with the design of man-supported observational programs in orbit.

As currently conceived, the ATM project can yield a scientific return comparable to or better than that expected from AOSO, and may be accomplished with an incremental investment which is not unreasonable in the light of AOSO costs, since the launch vehicle and basic spacecraft components are already purchased for the Apollo program. (The project would therefore go forward only if the launch system is not required to meet contingencies in project Apollo.) Unfortunately the project concept of ATM is far from an optimum arrangement, and would not use man in the mode of operation for space astronomy which we recommend below (and discuss in appendix A). This is in part because the project is based on the contingent availability of a manned system which was designed for quite another purpose, and in part because too little time remains available for engineering developments which could permit the astronaut in orbit to contribute more importantly to the reliability of the scientific instrumentation and could provide for the direct operation of the instruments by astronomers on earth using telemetry links.

Although we recommend that the first solar ATM mission go ahead, we urge that it not be conceived as an optimized system for a general purpose earth orbital observatory. Vigorous efforts should go forward at once to develop a space astronomy program along lines that make a more nearly optimal use of man and hardware, both in orbit and on the earth.

Astronomical observations from earth orbit.—The potentialities of astronomical observations carried out by means of facilities in earth orbit fulfill

most, and perhaps all, of the requirements discussed in Section II: Rationale of the U.S. Space Program, to serve as a major scientific focus of the U.S. space program in the 1970's. In particular:

a. Regions of the electromagnetic spectrum from long radio waves to X-rays are open to detection from orbit, with instruments which in many spectral regions can see objects much fainter (hence more distant) than those seen from earth. Furthermore, the freedom from atmospheric scintillation makes possible, in principle, dramatically improved spatial resolution and image formation, both with telescopes and interferometers.

b. These potentialities can have great impact on the science of astronomy; particularly if closely integrated with concurrent ground based studies. This is amply demonstrated by the experience in the combination of radio astronomy and optical astronomy leading to the recent discovery of quasars and by the latest discoveries of strong X-ray sources with small rocket instruments, and their identification with optical sources. Space observations may even permit the detection of planets orbiting about other stars.

c. Some of the scientific questions which may be answered by space astronomy involve the origin of the universe, the nature of its evolution and its ultimate destiny. With astronomy, moreover, theories of relativity and gravitation and the various cosmologies can be critically tested. These questions have always had great importance to mankind and motivated the early beginnings of modern science; they still constitute the most intellectually profound questions of physical science. In addition, there are possibilities that through the search for planets of other stars and the search for spectral indications of organic molecules, astronomy may contribute significantly to solution of the question of whether life exists in other parts of the universe.

Astronomy is therefore an appropriate choice as a primary goal in our space program. We envisage an evolutionary development of earth orbiting astronomical facilities designed to take advantage of the unique opportunities which are offered by observations from space.

We believe it will be technically feasible to work toward the objective of keeping these astronomical facilities contributing useful results over indefinite periods of time, if their maintenance and modification can be carried out in orbit. While each of the facilities for the different wavelength regions—X-ray, optical, and radio—are of unique construction, they are of a general purpose character in the sense that there is an enormous number of objects to be observed in the various regions of space. During the early part of the decade these telescopes may become obsolete as engineering designs are improved. One would hope that in the middle to late 1970's, in-flight maintenance and changes in auxiliary instrumentation at the telescope focus would give greatly extended useful lifetimes at lower cost than full spacecraft replacement. It seems unlikely that manned attention to the spacecraft need exceed a 2-week span for each repair or modification operation. Such missions might be required once or twice per year. Thus, we anticipate that in the latter part of the decade we will have gained necessary experience, both with astronomical instruments in orbit and with manned operations, to make a permanent set of facilities, attended by man from time to time, more desirable and less expensive than continued replacement of such facilities when they fail or become obsolete.

The collection of astronomical instrumentation which we are recommending will be of such unique scientific potential that we may anticipate the desire of very many astronomers to have access to it. In earthbound observatories the time required for data analysis and interpretation is typically an order of magnitude greater than that required for acquiring observations, with the result that typically about ten observing teams share a single telescope. With the large orbiting facility, we therefore expect a requirement for the efficient scheduling of telescope time, according to scientific priorities, among a great many observers. This will require that the ground control facility be in broad-band communications with the observatory and be capable of guiding and operating it from the ground under the direct control of astronomers in the ground facility. It will also be necessary to find a new institutional arrangement through which priorities can be assigned, astronomers can gain effective access to the space instruments, and decisions about the next modification of the instruments can be made. This institution will be similar to the present "national observatories" in that it would provide access for the whole astronomical community and provide the engineering support (in this case in orbit as well as on earth) necessary for such a large-scale facility.

The Panels have studied the Space Science Board recommendations concerning earth orbital astronomy as well as other proposals that a major effort be concentrated on a very large orbiting telescope (of perhaps 120-inch aperture). While we feel that ultimately—perhaps in the late 1970's—the very large orbiting telescope will be feasible and may command a high priority, we believe that it would be a serious mistake to embark on this single objective now to the exclusion of a more "evolutionary" approach. For scientific as well as technical reasons, we urge an immediate start on simpler instruments which can more dramatically exploit the new access to unknown regions of the spectrum—such as X-ray and gamma-ray telescopes, and relatively inexpensive submillimeter instruments. In addition, a reflecting telescope for the ultraviolet, visible and infrared of 40-to-60-inch aperture should be placed in orbit at the earliest practical date if diffraction-limited resolution can be obtained with available technology. The argument for this evolutionary approach follows directly from the great scientific impact which we expect these new facilities to have. If we are correct in this expectation, it is essential that the program be planned in such a way that the most expensive and ambitious instruments profit in their conception and design from the discoveries made using smaller ones which are more quickly deployed. The possibilities of large optical interferometers, X-ray telescopes, low-frequency telescopes, and other instruments never used on a large scale

before are such that it is unwise to attempt to predict at this time the nature of the highest priority large instrument for the program in the late 1970's.

Recommendations.—a. We recommend that the government adopt as a primary goal in the application of space technology for scientific purposes a program leading to the establishment in earth orbit of a number of astronomical facilities, which by the end of the decade of the 1970's will constitute an orbiting astronomical observatory capable of—

(1) exploring the full range of the spectrum not accessible from the ground with all the attendant advantages of instruments in orbit such as diffraction-limited resolution and coherent detection over large base lines,

(2) scientific control directly by astronomers on the earth, and

(3) extended useful life through intermittent maintenance and modernization by servicing in orbit using trained engineering personnel.

b. We recommend as the initial step (to be accomplished by 1970, if possible), the construction of a 0.1 arc-sec resolution telescope of about 40-inch aperture with guidance and auxiliary instrumentation superior to that planned for OAO, and the construction of a first generation set of specialized telescopes for the previously inaccessible wavelength regions designed to make preliminary surveys and demonstrate the feasibility of instruments of higher resolution and aperture. In this first group of instruments the cost will be dominated by the optical telescope.

c. We recommend for the middle 1970's a second generation of X-ray, gamma ray, submillimeter, and radio wave-length instruments, utilizing the experience gained from the 1st generation instruments.

d. We recommend that around 1970 a decision be taken regarding the optimum evolution of an optical telescope of ambitious size.

e. We recommend that NASA study suitable arrangements for working with the scientific community for the purpose of making most effective use of the investments in this astronomy program, and note that the ad hoc committee appointed by Mr. Webb in the spring of 1966 and chaired by Professor Norman Ramsey made a valuable step in this direction. The nucleus of a suitable organization should be formed as soon as possible, and should be charged with assisting NASA in the formulation of the detailed goals, and recommended facilities to achieve them, for the earth orbital astronomy program.

f. We recommend that attention be given to the excellent opportunity for international cooperation which is inherent in this space *observatory concept. Not only can the time this instrument is used be shared with observers from other nations, but they could develop their own specialized auxiliary instrumentation to be placed for a period of time in the focal plane of the space telescope, thus providing them with unique data obtained through instruments of their own design without the tremendous cost of launch vehicles and telescope construction.*

g. We note that the trend of recent years has very substantially reduced the fraction of the total cost of low earth-orbit unmanned space science missions which is invested in the launching rocket. The high cost of solving quickly the very troublesome problems of integrating a variety of independent scientific payloads into a large multipurpose satellite (such as OGO) may not be worth the advantages of using fewer but larger boosters. Thus we find that the independently planned and executed small satellite or sounding rocket experiment has great utility and we recommend that adequate provision be made for a sufficient number of rocket probes and small satellites to permit the testing on a modest scale of the new observing concepts in order to be sure that our major facilities represent the very best instruments that ingenuity permits. Nonetheless, we see the advantages of larger "palette" type payloads, with weight to spare in order to gain higher reliability and short response time; and urge studies to find means for minimizing the payload integration problems so that such multipurpose spacecraft can prove cost effective.

h. Finally, to insure the scientific effectiveness of its work in earth orbital astronomy, we recommend that NASA take the initiative necessary to insure that space-based and ground-based astronomical facilities and research programs are developed in consistent and complementary ways. In particular, we foresee the need for much more extensive ground-based observing capability, particularly in the southern hemisphere, if the recommended program of earth orbital astronomy is carried out.

Space applications—Manned and Unmanned.—Introduction.—Satellite technology has a number of direct applications to the economic and social well-being of the country, in such diverse areas as communications, meteorology, navigation, geodesy, and perhaps surveys of forested areas, the sea and shipping, agricultural growth, snow cover, and so on. Agencies other than NASA are actively investigating some of these areas. For example, DOD is developing its own communications system adapted to its special requirements, and is active in other applications of space. Thus, while development of space technology has already contributed substantially to our security in the direct military sense, DOD has also been involved in major new technological developments which can pro-

vide a wide range of civilian applications. An important problem for the next few years will be to identify, to declassify where necessary, and to encourage the transfer of all appropriate developments to the civilian community.

A major fraction of the space applications program has, however, continued to be done under the aegis of NASA, and it is to these NASA applications that this section is principally addressed. In contrast to the large part of the NASA effort devoted to space exploration and space science, these applications can and should be subjected to analysis as to the real and tangible benefits they promise and as to their cost effectiveness, as compared with other methods of achieving the same ends. At the same time, great care must be taken not to inhibit development of novel approaches which may, with technological development, improve their attractiveness.

Almost all cost studies of satellite programs indicate that the orbital life time is one of the most important determinants in establishing the costs of the system. The launch vehicle and payload are usually expensive items and, of course, they must be written off each time a satellite fails. Thus, there is a great cost difference between expected life times of the order of a year or so and life times of the order of perhaps 5 or 10 years. A major practical target in NASA's further work in applications technology should be, therefore, the development of highly reliable, long-lived systems.

Communications satellites.—Even though the greatest progress in space applications so far has been in the area of communications satellites, it is important that the country continue to improve its communications capabilities. The population growth and increased standard of living have led to a very rapid increase in the number of communications devices, such as radios, televisions, telephones, etc. Worldwide economic activity has increased and its dependence on reliable communications has increased. The computer is the heart of a broad new technology that embraces information storage and retrieval, data analysis, display and electronic printing. Computers are now being gathered into growing networks linked by high capacity communications channels which could be supplied by satellites—in addition there is the important possibility of utilizing satellite TV relays as an important ingredient in new educational systems, particularly in the developing nations.

A commercial communication satellite system now is mainly the responsibility of the Communication Satellite Corporation, but NASA has a responsibility for research and exploratory development for space communication techniques.

A large variety of worldwide programs to monitor the ocean, atmospheric, and terrestrial environments which may come into being in the next decade suggest the desirability of a worldwide space-based telemetry system capable of relaying to central data handling stations the inputs from thousands of automated instruments in the field. One such system is already under intensive study—the world weather watch, which requires real time data collection from thousands of balloons and surface stations. In addition to efforts in these areas, the NASA program plan envisions development and flight testing of satellites in the 1970–75 period to provide: (*a*) communications services to many small mobile terminals such as aircraft, spacecraft, ships at sea, and land vehicles, and (*b*) voice broadcasting and television to educational television and distribution facilities. Beyond 1975, it is planned to demonstrate the ability of satellites to transmit television programs directly to home television receivers.

Weather satellites.—The operation of weather satellites has improved forecasting in a substantial way. The primary utility at present is for cloud cover observations in remote areas. Satellites make it possible to pick up major storm centers, such as hurricanes, in an early stage of development, and this has led to a substantial improvement in forecasting the course of hurricanes, typhoons, and other large storms. For example, on the average, ten to twenty storms of hurricane intensity develop annually in the eastern Pacific, off the coast of Central America and Mexico. This area is almost devoid of observing stations and not frequently transited by ships. As a result, it is one of the great blank areas of the world as far as weather information. With satellites, it is now possible to monitor storms in this area.

In addition to providing cloud cover data of importance to forecasting, satellites are also obtaining information regarding the infrared radiation balance for the earth. This is of significance in studying the general circulation, and will very likely lead to significant advances in the numerical modeling of the atmosphere.

Cloud cover and infrared observations, however, do not solve the problem of weather prediction. For much improved long-range prediction, e.g., of 10 to 14 days, determinations are needed of temperature, winds, and humidity averaged over substantial volumes (10 square miles by 500 feet), rather than only scattered point observations. A number of systems have been proposed and are under development in industry and universities for probing the atmosphere at a distance, using microwave and infrared regions of the spectrum. It is quite clear that within the coming decade, systems will be available, either using probes at a distance or using some form of constant level balloon system with satellite data collection. These will permit a much better sampling of the atmosphere and will enhance forecasting capability. The economic returns for such forecasting capability have been documented in numerous studies prepared by the Weather Bureau, and they are sufficient to justify the importance of continued developmental work in the area of meteorological satellites.

Other applications.—There have been a number of proposals to use satellites for surveys of our resources. These would involve examination of geological, agricultural, and forest resources, the use pattern of urban and metropolitan areas, and similar activities. On the whole, the studies undertaken have not yet presented a convincing case that such survey programs can best be carried out by satellites.

Numerous other applications of satellites have been suggested. These include: iceberg patrol, forecasting of wave heights, a system to provide detailed information on the location of all merchant ships, a system to provide an inventory of water resources, systems to monitor pollution in the atmosphere, much improved navigational systems, etc. Each of these applications deserve a careful study which would include an assessment of the potential economic benefit. The Panels believe the potentialities of the use of space technology are far from being realized fully, and that an intensive program of study should be undertaken to examine these possibilities. Such programs should be undertaken in cooperation between NASA and the user agency. For example, we would expect that the Coast Guard and NASA would examine the question of iceberg monitoring, the use of satellites in sea rescue operations, etc.

Recommendations.—In summary, we recommend:

a. That a far more intensive effort be carried out to examine the applicability of satellite technology to the missions of all the Federal agencies. Such studies should take into account not only technological possibilities but the benefits, economic and other, which might be derived from satellite technology as compared with other methods. For many purposes, it would appear that unmanned satellites are the preferred way to meet such possible requirements.

b. That, whether the proposed space application systems are manned or unmanned, a reasonably clear case of potential utility must be made, which includes an assessment of potential economic benefit, before significant development costs are assumed. This is particularly important since the successful development of advanced technologies has greatly expanded the opportunities for space applications programs. With the wealth of opportunities available, it has become increasingly important to provide for an optimal selection of those which are suitable for continued support. We must emphasize that a great deal of space technology has passed the point where the demonstration of mere feasibility of a particular space application has any technological or prestige significance.

c. That, before a manned earth resources survey is included in the Apollo Applications Program, detailed cost-benefit studies be completed which treat manned versus unmanned methods for accomplishing these tasks.

d. That a careful examination be made of the potential role of man in the weather satellite programs.

Post-Apollo production rates for the Saturn V, Apollo Spacecraft Modules, and Uprated Saturn I.—Introduction.—We have reviewed the arguments which have been advanced to demonstrate the economies which will be realized by maintaining production rates of the Saturn V, the Uprated Saturn I, the Apollo Command and Service Modules, and the Lunar Module of at least four to six per year. We are impressed by the magnitude of the investment which has been made to provide the production organization and facilities for these vehicles, and are aware that utilization of these capabilities at lower than capacity will necessarily result in "inefficiencies," i.e., in higher costs per unit produced. However, the major cost of a space mission usually resides in the payload. In any case the total costs of missions utilizing Saturn V or Uprated Saturn I systems are so large that only those should be flown which have a clear and timely relevance to worthwhile objectives. This implies that in the overall picture economies in booster production will play an appreciable but not major role. Our own analysis of mission requirements, which follows, is necessarily tentative and will certainly need revising after the initial manned lunar landings.

Initial vehicle requirements.—At least two Saturn V/Apollo systems per year will be required for continued lunar exploration during the immediate post-Apollo period. We believe a third complete system should also be built annually as a backup, and, at least for a few years, a fourth should be available for other probable missions, manned or unmanned.

The question of continued production of the Uprated Saturn I launch vehicle is less clear and in the Panels' judgment needs further study. The payload capabilities of the Uprated Saturn I are not significantly superior to those of the Titan III M, while the launch costs of the Uprated Saturn I are about double those of the Titan III M. Nevertheless, we think it appropriate to continue production of a minimum number of Uprated Saturn I vehicles and associated spacecraft in order to provide additional time to analyze fully programs for which these systems may be useful, and to provide the number of vehicles for storage that are judged adequate to the needs of the post-Apollo period.

Space ferry systems.—Because of the continuing requirements for manned and man-attended systems we visualize that an important problem will be posed for a long time by the cost associated with taking men to and from orbit. If it should eventually turn out that men can be usefully employed in space for very long periods of time without a return to earth, ferrying costs may be relatively small no matter what sort of vehicle and spacecraft system is used for crew rotation and resupply. In the short term, however, we must assume relatively frequent crew rotation with a consequent need for ferrying. The three launch vehicle/spacecraft candidates for such uses are the Uprated Saturn I/Command Module, the Titan III M/Command Module and the Titan II/Gemini B (including growth versions on Titan III cores), and the cost per astronaut transfer using any of these is substantial. The two spacecraft alternatives differ in several important repects: the Gemini's carrying capacity is limited to two astronauts while the capacity of the Apollo Command Module can probably be raised from three to four astronauts without major changes, and subsequent extension to carry six

astronauts has been proposed. Moreover, the Command Module's heat shield and structure are suitable for reentry at lunar return velocities which also make it suitable for recoveries from high (e.g. synchronous) earth orbits, while the Gemini heat shield would have to be upgraded before it could be used for this type of mission.

A careful study and evaluation needs to be made concerning the relative advantages of the various launch vehicle-spacecraft combinations during a typical 60-day "double MOL" mission. This study should consider, *inter alia,* missions involving four (or more) astronauts using the Uprated Saturn I/4 man-Command Module (or the analogous Titan III M/4 man-Command Module) for delivery of part of the crew (the remainder having been delivered in MOL) and for its return (in units of four) as contrasted to use of the uprated Gemini Launch Vehicle/Gemini systems with the greater flexibility for commuting and for partial crew removal in emergency without terminating the mission. In making this evaluation, the fact that the Apollo Command Module systems would permit missions to scientific installations (or "space stations") beyond the Van Allen belts (whereas the Gemini system would not) should be given appropriate weight.

Recommendations.—In summary we recommend:

a. That the Saturn V vehicle continue to be produced, but that until additional requirements are clear, the post-Apollo Saturn V production rate be fixed at 4 systems per year.

b. That production of the minimum possible number of Uprated Saturn I vehicles be continued, pending an analysis of the long-range utility of this launch vehicle, storing those systems not needed.

c. That NASA make a study of the feasibility of a four-man and six-man Apollo Command Module ferry-system and also a comparative evaluation of the Apollo Command Module launched either by an Uprated Saturn I booster or by a Titan III-M booster. This should be compared with a ferry system utilizing the Gemini spacecraft launched with variants of the Titan II booster. For the longer range, studies should be made of more economical ferrying systems, presumably involving partial or total recovery and reuse.

Manned space stations.—Introduction.—The Panels' work in the area has been complicated by the multiplicity of the concepts advanced under the rubric of "space station." Accordingly, our first step is to clear up the confusion by adopting the following definition. By a "space station" we will mean an installation in earth orbit which is to be occupied by men on either a transient or permanent basis, and which is intended to be used for an indefinite period through repair, modification, resupply, and crew rotation. Any space installation not meeting these characteristics should be identified as a type of spacecraft or special purpose satellite.

Using this definition, a number of the "space station" proposals which have been presented to us fall into the spacecraft/satellite class. For example, the present *MOL* is an approved spacecraft with a 30-day lifetime but with capabilities for answering several questions of more general physiological and psychological interest. Interim systems of this kind can be useful and might well be used, but are not space stations.

Justification for a space station.—The primary justification for a station with an indefinite lifetime is that NASA must deal with the space environment in almost all of its planning for manned missions, and needs to make long-time studies in this environment on a systematic basis. Furthermore, although radiation and vacuum conditions can be duplicated on earth, we have no way of duplicating zero-g for extended periods of time. If the manned space effort is to continue, experimental facilities to permit these studies are necessary. The simplest solution appears to be permanently manned stations in low earth orbit, at altitudes between the height at which radiation is a problem and that at which orbital decay becomes significant. The immediate justification for such a facility is that it will give us direct experience with the behavior of human beings in zero-g environments for long duration flights, as well as the development and arrangement of components for life support systems which will, with redundancy and repairability, be able to function for periods up to 2 years. These are, of course, the times associated with actual interplanetary expeditions.

Although the direct questions of confinement and the effects of zero-g on human beings are the primary justification for such an experimental facility, it would also serve other useful purposes. For example, fundamental biological questions in the space context frequently call for studies on the effect of zero-g environments on lower organisms such as bacteria. To make such experiments scientifically profitable, it is desirable to have cultures attended by human beings for a long enough period of time to observe mutations during many hundreds of successive generations. The proposed space station would be a natural platform for such activities.

The space station should also be envisaged as an experimental facility directly useful in a systematic approach to many engineering problems in manned space flight, for example, in evaluating the utility of "telefactor" or remotely controlled manipulative systems in performing complex tasks outside the spacecraft. Also, it would provide a facility for investigating extra-vehicular activity (EVA) in a systematic way, including problems in the design of space suits, tools, and procedures for their use in a zero-g environment. Recent experiences with Gemini have shown how important it is that such technological problems be thoroughly mastered.

Finally, the space station would permit us to address ourselves to many basic enginering questions, particularly in the handling and behavior of fluids in zero-g environment. From convection effects in the cabin atmosphere on the one hand, to heat exchangers and similar devices in life support systems on the other, there are many phenomena which on earth

depend fundamentally on the existence of the earth's gravitational field. We should study these before committing ourselves to particular designs for long-term space use, realizing that the best way to get trustworthy information is in the zero-g environment itself.

A particularly important special case of such engineering problems involves possible refueling operations. Several approaches to the propulsion question for interplanetary rockets involve the transfer of fuels ferried up from the earth's surface, perhaps by a Saturn V booster, to a thin-skinned, lightweight orbiting vehicle which makes the actual mission. Pumping and handling of such fuels, which may be cryogenic, should be experimentally studied in a zero-g environment before we commit ourselves to a specific propulsion system.

Choice of booster.—Presumably, the practical booster choice in providing such a facility is between an Uprated Saturn I (or Titan III) and a Saturn V. The Panels are inclined to urge strongly the use of the larger vehicle, since the choice will have an effect on the completeness and efficiency with which the program can be carried out. We need the basic information from the facility at an early stage in the development of a program for manned planetary exploration and we should not cramp or delay the facility design because of limitations to orbital weight. While a closed-cycle life support system is probably essential for actual interplanetary flights, and will be developed and tested in the space station, it ought not be the pacing item in the establishment of the station. Dependence on this more advanced system can be reduced by simply launching enough life support supplies to maintain the station for a substantial time using a proven life support system. Research and development on various components of closed-cycle life support equipment and their interconnections could then be carried on in the space environment with the more conventional life support systems as a backup. These illustrative comments are meant not so much as specific suggestions but rather to emphasize our belief that the large booster capability we now have can be, and should be, used to its maximum advantage in shortening the time needed to acquire an operational capability. It can be so used because large payload capability enables the redundant use of cruder (and heavier) systems to obtain reliability or long life at a substantially earlier time than is possible with more payload limited and, therefore, necessarily more sophisticated hardware and techniques.

Summary.—To summarize, our main reasons for supporting an early space station development are these: (i) very prolonged (hundreds of days) studies of men, animals, and other biota under controlled conditions and under the scientific direction and supervision of experts in the space station; (ii) probable eventual needs for permanent installations of complex scientific and applications equipment for which manned maintenance and adjustment turn out to be feasible and essential to assure continued usefulness of large investments; (iii) probable eventual needs for an engineering installation in earth orbit to serve as a base for developing and testing vehicles, spacecraft, and their subsystems for very long term missions in earth orbit or in interplanetary missions.

Of these reasons, the question of how long it will be possible to have man stay in a space station without serious impairment of his capability of performing the functions for which man is the sole practical tool is the most significant. The answer to this question will determine the economics of man's usefulness for any space application and must be answered to permit rational design of equipment for prolonged space journeys. Because of this, we believe that the space station which should be considered first is that for prolonged biological and biomedical investigations. We have said that we expect the MOL program to provide important pertinent information on man's capabilities by 1970–71, and have suggested that MOL-type systems be employed to extend biomedical studies to groups of at least four men and for durations of the order of 60 days. We see no reason why the results of such studies could not be available by 1971–72.

The Panels urge that these studies include examination of the advantages in timing and flexibility which may be gained by use of the large boost capability of the Saturn V (which becomes available for post-Apollo missions probably in 1970).

Also, it seems to us, that by 1971–72, we should understand, on the basis of Apollo and MOL experience, the most serious limitations on man's capability of performing useful work either in a "shirt sleeve" environment in a space vehicle or in a space suit. With such information we could then decide (1971–72) whether to begin planning a new space station or a space station annex for the assembly and housing of an astronomical observatory in which man would be transiently employed along the lines we have discussed.

On the question of early experiments on man's capabilities in space, we have reviewed NASA's proposal for the use of the airlock and the spent second stage of an Uprated Saturn I vehicle as an orbital workshop for experiments in space. This system would have value, for example, in connection with studies of the effects of exposure to the space environment for longer periods than would be reasonable using solely the modified Apollo Command and Lunar Module systems. Although, as previously suggested, we are inclined to the use of MOL systems for durations of up to 60 days, and of newly designed systems for still longer exposures, the orbital workshop proposals do appear to offer a unique opportunity for an early test of man's capability to do useful work in a zero-g environment both in and out of his space suit. The critical questions are: (*a*) whether the pace of the overall manned flight program necessitates the acquisition of these longer duration flight data substantially earlier than available from the MOL, and (*b*) how the orbital workshop will be integrated into plans for studies of men in space for much longer times.

Recommendations.—Accordingly:

a. We recommend that programs of studies and advanced developments be initiated promptly with the objective of a launch in the mid 1970's of the first module of a space station for very prolonged biological studies of man, animals, and other organisms in earth orbit. Such a station should be designed with consideration of its possible role in support of earth orbital astronomy. We leave the date for first operation of such a space station quite flexible, because of our belief that the rate of investment in this project will be a sensitive function of the national decision on the desired pace of effort toward manned planetary travel.

b. We recommend that plans be developed for space stations with the necessary testing and monitoring facilities for the needed tests in space of equipment for environmental control, power supply, communication, etc., especially with regard to their long-term reliability. Attention should be paid to the possible advantages of combining such stations with those for biological studies, either through enlargement, rendezvous, or initial orbiting of a larger station.

Advanced research and technology.—Introduction.—A space effort involving manned and unmanned space exploration, long-term earth satellites for science and applications and lunar exploration must presuppose a vigorous program of relevant research and development in several areas, such as: human factors, life support, space power (both in NASA and the AEC), propulsion (both in NASA and the AEC), laser communications and telefactors or man-machine systems.

A major unified program such as Apollo with an explicit deadline for success compels a concerted effort toward developments leading to immediately usable technical results. The basis for those results is, unfortunately, quite often the state of the art of the technology at the beginning of the program. In a broad-based program such as we envisage for the 1970's there will be a need for an advance in the state of the art. Our concern is that with a limited total budget a scarcity of relevant research and technological development programs may result. Such a shortage could inhibit the balanced development of those new technologies which subsequent, more demanding missions will eventually require. For example: (i) Aside from solar cells and radioisotope thermoelectric generators (up to 1–2 kw) we have no electric power systems which can be designed and built with performance and reliability characteristics adequate for space missions lasting hundreds of days; moreover, while solar cells may provide up to 30 or 40 kilowatts at one earth radius, they are not practical for some missions; (ii) Prolonged missions will require trouble-free performance of complex mechanical and chemical processing systems for durations beyond the present state of the art; (iii) It appears impractical to plan for sufficient redundancy in components to assure adequate reliability for the critical subsystems needed to support an interplanetary manned mission so as to

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avoid the necessity of crew maintenance and repair, but we do not know as yet how to design subsystems to insure the feasibility of such arrangements.

Relative to the total effort envisioned for post-Apollo programs, and particularly as preparation for design of systems for early manned planetary exploration, the current available financial support for advanced research and technology is not adequate.

Recommendations.—Accordingly, we recommended:

a. That the NASA efforts in advanced research and technology be maintained at a high level with particular attention to providing the demanding technologies needed to meet requirements for long-duration space travel, with the level of effort adjusted to the decision on the anticipated schedule for producing a manned planetary capability.

b. That NASA should undertake major new missions on a time schedule flexible enough to permit incorporation of new technological developments along the way. In addition, NASA should actively encourage the process and funding of technological advance, as discussed in item (a) above. Going ahead with forethought to future needs can lower mission costs and make success more rapid, particularly in such very difficult undertakings as manned planetary exploration.

c. NASA should utilize the decrease in manpower needs for contract management as the Apollo program passes its peak activity level to reorient and increase NASA Centers' activities in the research, development, and engineering activities which must precede the development of flight systems for long-duration space missions, both manned and unmanned. Because completely new concepts in science and engineering may be needed, NASA should also try to increase the degree of influence on its programs by the creative research capabilities to be found in both universities and industry.

Integration of manned and unmanned space exploration.—Introduction.—NASA's Office of Manned Space Flight has demonstrated notable competence in organizing and managing major space projects, as witness the successful completed Gemini program and the generally excellent state of the Apollo program. The management structure involved here must be preserved and used to full advantage. In the Panels' judgment, however, the overall NASA organization, while logical now, is potentially awkward and illogical for the planning of major new space programs. This problem will arise because NASA's organization is divided according to capabilities and techniques rather than broad space objectives. While the present organizational form was perhaps ideal for developing new space capabilities, it is now likely to complicate rational application of such capabilities in meeting future program objectives. For example, we believe that man should

be used in space flight only when his presence contributes in an important way to the exploratory and scientific objectives. To insure that he is used in this way implies much greater integration of manned and unmanned mission planning than is reasonable to expect from NASA's present arrangements.

We have considered a number of specific ways whereby NASA might achieve the integration we believe is needed. In view of NASA's demonstrated capabilities in organization and management, however, we think it sufficient merely to emphasize that a new point of view is needed and to suggest some lines along which it might proceed.

Recommendation.—We recommend that NASA study the advantages of adopting a planning and decision-making structure which emphasizes program objectives rather than the means used to attain them.

International cooperation.—Space exploration, space science and space applications all constitute areas where international cooperation is particularly appropriate. For some types of cooperation it is appropriate that the United States take the initiative in developing opportunities for international use. An example would be to make its earth orbiting astronomical observations available to scientists of all nations. In other areas, notably for the very expensive programs of planetary exploration, deliberate coordination and, whenever possible, actual integration of U.S. efforts with those of other nations makes very good sense. Cooperative efforts between the United States and the USSR could not only lead to a more efficient overall program but give an additional justification to the program itself. The Panels believe that possibilities for international cooperation should be kept constantly in mind as the space program develops. NASA's own efforts toward international space programs should be expanded. In addition there should be continued encouragement to other agencies, notably the State Department, the Arms Control and Disarmament Agency, the National Science Foundation and the National Academy of Sciences to study and, where possible, actively support international programs in space, including the fostering of cooperative efforts through organizations such as the International Council of Scientific Unions.

Section IV. Budgetary Implications of Various Program Levels

Introduction.—In the foregoing sections of this report, the Panels have outlined the problems regarding the future of the space program, discussed the rationale for the program, and provided a number of specific recommendations and supporting discussion in an attempt to answer the basic question "Where does the nation go in space in the post-Apollo period?" Since the Panels' recommendations do not constitute a single specific program but can be implemented in a variety of ways and on various time scales, and since several specific program decisions are implicit in the Panels' recommendations, it appeared desirable to provide an analysis of alternative programs and associated budgetary levels which could result from these recommendations.

For the purposes of this analysis, a single, relatively distant fiscal year was chosen, 1972, and three illustrative programs were constructed, A, B, and C.

In the multitude of possible space programs, it is clear that both the basic content and also the pace at which the program is carried out can be varied to achieve widely divergent budget levels. For example, a continuing program of lunar exploration, both manned and unmanned, can be conducted at a relatively low budgetary level, with a dual Saturn V launch every 12 to 18 months and with about two Surveyor-type unmanned missions during the interval between manned launches. The same basic program, if sharply accelerated to involve several missions of each type per year, could require relatively high budget support. To illustrate this effect, programs B and C were constructed so that both are consistent with the Panel's recommendations, but with the C program designed to be conducted at a somewhat more accelerated pace than program B.

In considering program alternatives a point of particular importance is to identify the major program choices which will be available in the coming years and then to assess the effects of different decisions about these choices. Among the major decisions to be faced are the character and pace of continued lunar exploration, the relative emphasis upon earth orbital applications programs, the level of support of space science, particularly astronomy, and the relative mix of manned and unmanned efforts. Of these program decisions, the one with the largest impact upon the size and the content of the program in the early 1970's is manned planetary exploration. As noted in Section III, the Panels based their recommendations on the expectation of eventual manned planetary exploration and have therefore included programs which would produce needed answers for a decision on a particular manned expedition. Another alternative is, of course, to postpone indefinitely any consideration of manned planetary exploration. This is a defensible choice to make if the desire is to maintain a space program, but to keep the program at a relatively low budget level. Program A is based on this choice; it abandons programs which bear directly on manned planetary exploration but assumes that the majority of the other recommendations of the Panels would be carried out at about the same pace as implied by program B.

The important point to be made is that at any budget level a space program must be thoughtfully designed to ensure that the goals are reasonably consistent with the resources. With proper planning one can hope to maximize the effectiveness no matter what the budget level. Program A attempts to illustrate this at one low budget level. At the same time the Panels are conscious of a serious potential danger in attempting to carry out a space program at a very low budget level. It is possible that the technological and human challenge, the imaginativeness and popular appeal of such a reduced space program would be so small that it would not produce the important indirect benefits in technological excellence and national self-confidence that were discussed in Section II. If so, this would be a severe loss.

To increase the usefulness of this budgetary analysis, it would be desirable to develop an estimate of the costs associated with a decision at a subsequent time to change the objectives of the A program by reinstating the manned planetary mission as a goal. However, the complexities of the alternatives, and of the sets of assumptions that would be required before meaningful cost estimates could be prepared made such an effort impractical. But, it is probable that the costs in dollars and in time of such a change of mind would be substantial, depending, of course, on how many years had transpired before the change was made and the character of the technological progress made during these years.

An additional major consideration in comparing total budgetary levels and alternative programs is that of U.S. international prestige, as it might be affected by the course of competitive space accomplishments of the Soviet Union. Even though the United States now appears to have a position of overall leadership in space, the USSR could, by a sufficient acceleration and focusing of its efforts, attain a position of primacy in individual program areas, even if the United States were to proceed at the pace implied by program C. While we are aware that only the most vigorous of programs, probably with unrealistically high costs, could insure against such a possibility in all program areas if the USSR chose to concentrate its efforts in some narrow area, the probability of such an occurrance becomes increasingly remote at the higher program level.

Further detailed descriptions of the A, B, and C programs follow. The discussion is referenced to the major program categories used in Table 1, which shows the approximate total funding required for the alternative programs with percentage distributions shown to illustrate relative emphasis within them.

TABLE I

[Amounts shown in millions of dollars]

	Fiscal year 1972 Panel alternatives		
	A	B	C
Total program	$3,500	$5,800	$7,000
	Percent	Percent	Percent
Lunar exploration	8	4	6
Solar system exploration	16	10	12
Earth orbital operations	19	32	33
Advanced research and technology	11	10	11
Launch vehicle support	20	23	21
General support	26	21	17

Program A.—Total program.—This program assumes a decision to postpone manned planetary exploration for an indefinite period. As a consequence, certain major program elements may be dropped, and others continued at a rather deliberate pace. The principal elements which can be dropped or decelerated are those related to the qualification of man and the development of man-related support systems for long-duration space flight.

The principal foci for program A are: (*a*) a combined manned and unmanned program in earth orbit with emphasis on space applications and on the evolutionary space astronomy program described in Appendix B; (*b*) a program of continued lunar exporation; (*c*) an unmanned program of continued and upgraded planetary exploration.

Lunar exploration.—We shall assume that, having achieved the Apollo objective successfully, and having briefly visited two or three other equatorial sites with the basic Apollo system, a decision to continue manned lunar exploration would have been made. This decision would have taken account of the large expenditures in funds and in manpower in achieving the initial Apollo objective, the large investments in production and launching facilities that were a direct result of this program, and the rather minimal cost necessary to extend the capabilities of the basic system to provide additional stay-time and increased scientific return. Although the extension of the Apollo system contemplated in program A would provide this increased capability, further extensions to provide, for example, manned exploration of the higher lunar latitudes or a semipermanent lunar base would not be planned pending identification of the need for such an expanded lunar program. Furthermore, the pace of lunar exploration, both manned and unmanned, would be comparatively slow.

Solar system exploration.—With manned exploration of the nearby planets delayed indefinitely, greater relative emphasis would be placed upon the unmanned planetary program. This would be a balanced program, directed at both Mars and Venus, with progressively more sophisticated Surveyor-type soft-landed spacecraft planned for the mid-to-late 1970's. Consideration would be given to the development of hardware and procedures for the return of samples of the planetary material. This unmanned program could be conducted under the present Voyager concept, and in its early phases would essentially coincide with the presently planned effort. In parallel with missions to the two closest planets, there would be programs for the development of probes to the more distant planets, comets and asteroids. In fiscal year 1972, these missions would be in the preliminary development stage, and major funding would not be required. The sophistication required by the unmanned planetary spacecraft would, however, have an important impact in the advanced research and technology areas, in part because sterilization and reliability requirements would still probably be beyond the state of the art in 1972. In addition, a major developmental effort would be needed to increase the data transmission rate over greatly extended communication distances.

Earth orbital operations.—In the earth orbital portion of the manned space flight program, extended flights of the order of 6 months to 1 year or more would not be pursued, in the absence of the primary justification for them, preparation for long-duration planetary flights. Nevertheless, manned earth orbital operations would be continued at a constrained pace for the investigation of applications and science areas in which the use of man (e.g., to take advantage of this decision-making, observational, and manipulative capabilities) could prove to be an important, possibly a vital component in future programs. An example might be the emplacement of a large telescope into synchronous earth orbit with capabilities available to have it repaired and adjusted, or to change the instrumentation, while maintaining a wide band communication link with astronomers and engineers on the earth (see Appendix B for greater detail). Because of the generally limited scope of the earth orbital program under option A, a space station or large spacecraft for similar purposes would not be planned at this time. Under such circumstances adaptation of the Titan III should provide adequate launch capability, and production of the Uprated Saturn I would therefore have been discontinued.

Unmanned earth orbital operations are, for the most part, relatively independent of a decision regarding manned planetary flight, and therefore would be continued at the same level as in program B. This area includes programs in applications, bioscience, particles and fields, geophysics, and astronomy.

Advanced research and technology.—A rather marked re-direction of activity in this area would result from the decision to forgo manned planetary exploration for an indefinite period. Work on advanced long-lived

life-support systems and on large nuclear-heated hydrogen or nuclear electric propulsion systems would not be pursued. Improved space power systems would continue to receive attention because of needs in applications satellites and unmanned planetary spacecraft. In addition, the previously mentioned requirements for high component and system reliability and for sterilization, imposed by planetary exploration, will necessitate major programs in these areas.

Launch vehicle support.—Launch vehicle support for the above program would include continued minimal production of the Saturn V vehicle (at a rate of not more than 4 per year) for use in the unmanned planetary program, for lunar exploration, and for synchronous orbit astronomy missions. However, production of the Uprated Saturn I might well be terminated in favor of the lower cost Titan III/MOL combination for low earth orbital manned operations. Other standard launch vehicles would be produced as necessary to support the remaining unmanned programs.

General support.—The major categories within this area are Administrative Operations and Tracking and Data Acquisition. While the latter will remain relatively constant and independent of all but the most severe perturbations of the overall NASA program, the former item should be reduced to reflect the deliberate pace of manned space flight activity. In view of the lower level of effort some consolidation of NASA activities might be desirable; for example, one of the Centers might be eliminated by absorbing its program responsibilities into the remaining ones. Other activity, such as the Sustaining University Program, Technology Utilization, and Construction of Facilities would continue at a moderate pace.

***Program B.**—Total program.*—In the B program, the Panels have constructed an alternative to program A which illustrates the effect of a decision to proceed toward eventual manned planetary exploration, but at a pace which does not in fiscal year 1972 involve a commitment to a specific planetary mission or to a specific target date. The principal areas that will receive emphasis but which are not part of the A program, are qualification of man for long-duration space flight and development of long-lived support systems for manned flight. However, the emphasis in 1972 will be toward the development of technology and establishment of criteria for prototype planetary mission modules, not toward development of specific modules. Although no single dominating program goal would exist, most of the funding would be tied to the manned spaceflight program and for the large boosters needed to support this program.

Lunar exploration.—In the Panels' B alternative, expenditures on lunar exploration will be concentrated in extended Apollo missions to the Lunar surface (7 to 14-day stay-time, based upon a dual Saturn V launch with LM shelter/taxi and/or lunar logistics system support), and an unmanned Surveyor-type program involving the soft-landing of instrumented vehicles at the lunar poles and in remote areas of special interest for exploration and data gathering tasks (for example, as preliminary steps to manned investigation of these sites). In this respect, there is little difference between the A and B programs. An elaborate mobile laboratory (or a base providing 6-month stay-times) would not be developed at this stage, pending explicit identification of a need for these facilities. The Panels recognize that unusual findings in early lunar exploration could change this picture significantly.

Solar system exploration.—Solar system exploration in program B would be structured differently from program A because of a requirement for greater coordination between the unmanned and (eventual) manned portions. Also, in later phases the more advanced and sophisticated unmanned spacecraft envisioned as part of the A program would not be needed. Rather, emphasis would be placed upon obtaining that information about the planet which would be necessary to enable the efficient design of a manned landing system, and which would provide the data on planetary environmental conditions needed to ensure a successful manned mission. Specifically, in the Panels' B program, no further flyby missions are planned for Mars following the mission in 1971, the emphasis being shifted to orbiter/lander Voyager-type missions, while for Venus, assuming that the Panels' recommendation for a 1970 mission will have been accepted, additional and more sophisticated missions in 1972 and 1973 would be supported. The program other than for Mars and Venus would be supported somewhat more heavily in the Panels' B option than in the NASA program. It is intended that a spacecraft for distant planetary probes be developed and that missions to Jupiter be supported for 1972 and 1975. In addition, the Panels' program provides for the beginning of effort toward multiple-planet missions in the late 70's, but a specific commitment to these missions would not be made at this time.

Earth orbital operations.—In order to support the development of a capability for manned planetary exploration, certain aspects of manned earth orbital operations would expand appreciably in comparison with program A. In particular, in the intervening years, flights of progressively longer duration would have been conducted utilizing modifications to existing systems so that, by 1972, the development of a more complex laboratory module or space station suitable for biomedical studies of man and animals under zero-g for extended periods would be in its final stages. This module would also be useful as the basic unit in the construction of a low-altitude orbiting astronomical facility, and for other engineering tasks as described on pages 37–40. Manned synchronous orbit operations would also be continued for support of high altitude astronomical observations.

The character of support for unmanned programs in applications, astronomy, geophysics, and bioscience would remain unchanged, with funding at levels very nearly the same as proposed for fiscal year 1968.

Advanced research and technology.—The greater emphasis upon problems related to long-duration manned flight would provide additional

stimulus to the advanced research and technology effort. Among the areas that would require special attention are life-support systems, psychological studies, advanced propulsion systems, and high data rate long-distance communication techniques.

Launch vehicle support.—Continued production of the Saturn V would be funded, as well as a lower capability earth orbital system—either the Titan III/modified MOL or the Uprated Saturn I/CSM/LM, depending upon the results of the studies which were recommended in Section III. The latter launch vehicle system would be utilized for both independent earth orbital flights and as a ferry system for support of the long-duration space station module. Development of a high energy upper "kick" stage and integration of this stage with an existing vehicle for eventual use in unmanned deep space probes would be funded.

General support.—In comparison with program A, moderate increases would be necessary to provide adequate support in this area for the expanded programs which are suggested for program B.

Program C.—Total program.—Program C has been constructed to illustrate a program which incorporates the Panels' recommendations but in which the pace of the activity has been accelerated over that contemplated in program B. One of the many interacting factors that could serve to produce an accelerated pace would be adoption of a specific mission objective; for example, a manned mission to Mars by some fixed date, say 1985. Such a decision could provide a sense of urgency for supporting more liberally objectives such as the qualification of man for long-duration flight, the development of advanced nuclear, electric or chemical propulsion systems, or preliminary unmanned planetary exploration. Other factors, including effects of international competition, could also serve to bring about the increased overall pace, as well as additional emphasis to various specific aspects of the program. The Panels have not presumed to define the circumstances which would dictate a program of this scale. In the C option we have constructed a program which, although it does not assume adoption of the specific manned planetary mission goal, is not incompatible with such a goal. In any case, in fiscal year 1972 such a manned planetary effort would still be in its very early stages. On the whole, therefore, the C alternative may be characterized as a vigorous, expanded space program capable of supporting a manned planetary exploration decision at an early date.

Lunar exploration.—A vigorous program of lunar exploration would still, in fiscal year 1972, be based upon the modified Apollo system with dual Saturn V launches and utilization of the LM shelter/taxi for extended staytime and greater lunar surface mobility. Launches of this dual system would be conducted approximately every 6 months, instead of every 12 to 18 months in programs A and B. In order that this increase in manned exploration be effectively exploited, additional Surveyor-type unmanned spacecraft will be needed for site survey and for the exploration of remote areas of interest, such as the lunar poles and the higher lunar latitudes. Although development of a system with the capability of providing stay-times in the order of a lunar month or more, with mobility over the lunar surface of the order of tens of kilometers is not explicitly supported at this budget level, information gained in early lunar missions may indicate the desirability of this next step in exploiting the moon. In that case, additional funding for this development would be required.

Solar system exploration.—The program of solar system exploration in the C option (as in the B option) would be based upon Voyager-type soft-landed missions to Mars and to Venus, with the development of an advanced planetary probe for exploratory missions to the more distant planets, comets, and asteroids. At this budget level, however, Venus as well as Mars would receive a Voyager mission in 1975, in addition to those earlier missions supported at the B program level. As in the B option, these efforts would be part of a coordinated manned-unmanned plan of planetary exploration, and therefore extremely sophisticated follow-on unmanned missions would not be planned. The advanced planetary probe would be planned for a dual-vehicle launch to Jupiter in 1972, and again in 1975, with initial planning and program definition for execution of the multiple-planet flyby or so-called "Grand Tour" in 1977.

Earth orbital operations.—The largest portion of the space program in fiscal year 1972 (exclusive of launch vehicle production) involves manned earth orbital operations, and this is true for all three program options, A, B and C. In the B and C options, however, the character of the program differs significantly from that proposed in A. Specifically, in the C option, the program is based upon the development of a laboratory module of a space station for use in the qualification of man, and also the development and flight of an engineering test module for the evaluation of the many technical and systems questions which need to be answered before manned planetary flight can be attempted. The C program envisions the construction and launch of several major modules into low earth orbit for rendezvous and perhaps assembly via docking or tether into a major earth orbital facility. One of these major units could be a prototype manned planetary spacecraft, which would be tested and evaluated in earth orbit.

As in the B program, synchronous earth orbital astronomy would be continued, but at an accelerated pace. Geophysics and bioscience experiments, as well as the development of advanced applications technologies, will also be continued at a somewhat accelerated pace.

Advanced research and technology.—At the increased funding levels provided in the C option, greater emphasis would be placed upon advanced propulsion techniques and closed-cycle life support systems. Other areas would receive moderate level-of-effort increases as well.

Launch vehicle support.—In addition to production of the Saturn V vehicle, and other standard launch vehicles necessary to support the above

program, development of an advanced vehicle for unmanned deep space investigations and increased lunar payload delivery would be initiated.

General support.—No significant changes as compared to program B are programed in the level of administrative operations and other categories within this area, although it is realized that the buildup of contract direction activity related to a major planetary effort may cause a change in this estimate.

Appendix A. An Evolutionary Space Astronomy Program

Introduction.—From the earliest times, man has pondered his relationship to the universe. What is the nature of the stars? Do they have planets, possibly with life on them? How are the stars distributed in space? Is space itself finite or infinite? How did the stars, and indeed the universe, come into being?

The attempt to answer such questions has led to the construction of increasingly powerful telescopes, the largest of which is the 200-inch telescope on Mount Palomar, for the purpose of studying the planets, the stars, and the universe. By analyzing the spectra of radiation recorded with the telescope, and applying physical principles in their interpretation, detailed physical properties of stars have been obtained. It has been demonstrated that the stars, far from being immutable, are in fact transitory configurations of matter, forming out of hydrogen clouds in interstellar space, shining by means of thermonuclear reactions in their interiors, and ultimately ceasing to shine, either through a stellar explosion or by contraction to the objects known as white dwarfs.

Let us focus now on the particular contribution which can be made by telescopes orbiting the earth and used for observations of remote objects. Compared with their counterparts on the ground, such telescopes enjoy the advantage that light collected by them has not passed through the earth's atmosphere. Since the atmosphere absorbs, scatters, or refracts almost all of the radiation falling upon it, this advantage is very significant indeed. In fact, practically all of the information discussed above has been gleaned from a narrow band of wavelengths in the visible region, which is relatively unaffected by the atmosphere. Even in this range, however, the ability of large telescopes to record faint stars is limited by atmospheric scintillation—an irregular refraction effect which causes a sharp stellar image to diffuse and merge with the background. A large telescope (say 120-inch aperture) in orbit above the atmosphere with the finest possible optics and the ultimate in guidance can, in principle, yield extremely sharp images (down to 0.03 inch) and hence permit observation of objects hundreds of times fainter than its counterpart on the ground. Furthermore, such a telescope, when coupled with appropriate instruments designed for other wavelengths (such as X-ray telescopes and millimeter-wave antennas), can form a space observatory capable of observing the entire spectrum of radiation from X-rays to microwaves.

An indication of what could happen if the ultimate space observatory were to come into being can be drawn from the study of distant radio sources, such as quasars. These objects were discovered a few years ago when efforts were made to observe in the only other band of wavelengths which penetrates the atmosphere, the radio band. When large optical telescopes were focused on them, they were found to be optically faint—so much so that most of them had never been noticed before. Further measurements have been undertaken in the X-ray region, by means of sounding rockets above the atmosphere, with the result that some of the sources were found to be extremely powerful X-ray emitters. As if this situation were not unusual enough, the objects as a class appear to be the most distant objects known to man, with great implications for the structure of the universe.

We conclude that a well-planned and adequately supported program of astronomy using orbiting telescopes can contribute very significantly to the resolution of important scientific problems. By extending the range of accessible wavelengths and the levels of faintness, it can clarify the problem of stellar evolution and the origin of the universe. By permitting an increase in the sharpness of images attained, it can permit an attack on the existence of remote planetary systems, some of which may harbor life. And by increasing the power and spectral bandwidth over that obtainable on the ground, it can push even further the studies of remote objects initiated with ground-based instruments. It is worth noting that many of the general philosophical questions for which such a program has great implications have great interest for the general public. Therefore, such a program is a particularly appropriate major focus for the National Space Program.

Evolutionary space observatory concept.—If the challenging opportunity for fundamental investigation of the universe made possible by observations with space telescopes is to be exploited to maximum extent, not one but a number of different telescopes have to be put into operation—one by one. This multiplicity is made necessary by the many decades of the electromagnetic spectrum which are likely to contain the needed information.

a. X-ray and Gamma-ray astronomy.—X-ray astronomy is now rapidly approaching the end of a phase in which its potential has been exploited as far as is possible with small rocket systems (200 pounds to 120 miles; coarse attitude control, $\pm 2°$ pointing ¼ degree per minute drift). The broad capabilities for future observations can now be gaged with some confidence. We may expect to find approximately as many X-ray sources as radio sources (10^4—10^5); high resolution, both geometrical (1 arc second) and spectroscopic (0.01A) are technically feasible; variability appears to be as much a part of X-ray astronomy as it is of optical and radio astronomy. To exploit these capabilities and observational potentialities, we should progress from the present payload limitations in order of magnitude steps. Apollo and MOL class spacecraft in low earth orbit could carry large area detectors and X-ray reflection telescopes, weighing several thousand pounds and requiring power in the kilowatt range. Present technology

can produce a 100-square-foot, mechanically baffled detector and a 1-meter aperture, 10-meter focal length reflector that are compatible with either Apollo or MOL spacecraft.

Large area telescopes are simply multiples of presently developed modules. A 100-square-foot array (weighing 2,500 pounds) could be flown in the 1969–70 period (with an estimated instrument cost of $2M). Reflecting telescope design is well understood in principle and small-scale versions (20-centimeter aperture) have performed up to expectations in solar rocket astronomy. 1970 is a reasonable target date for a 1-meter-aperture telescope (weighing 1,000 pounds and costing approximately $3M for the telescope plus accessory instrumentation and data system). Both the large area and reflecting telescopes could be designed for fully automatic deployment and observational programing by ground command. Inclusion of the astronaut-engineer could increase the reliability of deployment, focus adjustment, and necessary component servicing within the first few days of operation. The instruments could then be expected to function unattended. The large area telescope provides electronically processed data exclusively; a reflecting telescope can operate with photographic imaging or point by point electronic scanning. The former method requires film return from orbit and resupply.

By 1975, the large area X-ray detector should have evolved into a general purpose survey and monitoring instrument. The reflecting telescope should continue to evolve toward the 10-meter-aperture, 100-meter-focal-length configuration (instrument cost approximately $10M).

The first observation of a discrete gamma ray source (in Cygnus) has recently been reported. The flux was somewhat higher than the most optimistic theoretical predictions. We may consequently feel confident that theoretical estimates for gamma ray astronomy in its broadest conception are not extravagant and that the instrumental developments now being initiated will provide adequate observational sensitivities. In the evolution of gamma-ray astronomy, we start immediately with payloads beyond the capabilities of the present Explorer class. Payloads in the one thousand to several thousand pound class, with square meter apertures and one meter to several meters path lengths are typical of first generation instruments. It appears that, from its very beginning, gamma ray astronomy will require launch systems of the order of Atlas and Apollo. A 1969–70 target date for gamma ray telescopes, in several energy ranges and with energy resolution sufficient to detect emission lines, is feasible. Deployment and alignment problems are minimal and only coarse pointing is required. Improvements in detector technology, including cryogenic components are proceeding so rapidly that one can only be optimistic about future developments. Astronaut participation can provide for substitution of improved components in a complex system which has a basic system useful life of several years. (Instrument cost $2M/telescope.)

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b. *Optical and ultraviolet astronomy.*—The present OAO program involves the use of mirrors up to 36-inch aperture but payload and power limitations severely handicap the instrumental and spacecraft reliability and the flexibility of the observational programs. It seems possible to achieve a diffraction-limited 40-inch telescope (0.1 arc second resolution) with a versatile complement of accessories, photographic capability and superior guidance (0.03 arc sec.) in the 1972–73 period. (Instrument plus platform cost, about $150M.)

In parallel with the development and implementation of the 40-inch-telescope program there should be intensive development efforts in connection with ultraviolet image converters and image orthicon systems, with adequate opportunities for flight tests and exploratory surveys on stabilized rockets (Aerobee class) and Explorer Satellites. In principle, it should be possible to exceed the efficiency of direct photography by more than an order of magnitude and to dispense with the problem of film handling in orbit. (A similar statement would apply to the photographic versions of X-ray telescopes.)

The 40-inch telescope will be an evolutionary step toward an ultimate instrument of 120-inch aperture in the late 1970's. (Cost of 120-inch observatory about $500M.)

c. *Solar astronomy.*—Solar astronomy requires its own specialized program of observations. At this time, there has not yet been a substantial scientific return from the first generation of OSO satellites. Several years of continuing OSO observations with the existing spacecraft design are essential to amortize effectively the investment in instrumental developments, and we may expect that fundamental scientific results will be derived. It is already well within the technological state of the art, however, to exceed greatly the present spacecraft capabilities in power, telemetry, data storage, pointing capability, payload volume and weight. These gains are achievable at no considerable increment in cost and it is important that a continuing solar observatory program be based on improved spacecraft versions. ($3.0M per OSO.)

The OSO program should be supplemented by a second generation solar observatory program beginning in 1969. Capabilities should include the accommodation of instruments up to 2 meters in length, 5 arc seconds pointing, less than 0.2 arc second per minute drift, photographic imaging and electronic imaging (instrument plus spacecraft, about $150M). The ATM is a major step toward this performance capability. A third generation solar observatory should utilize a large telescope (about 40-inch diffraction limited) as its collecting element. The development of this version should be coordinated with comparable telescopes for galactic and extragalactic astronomy.

d. *Infrared astronomy.*—The broad range from 1 micron to 1 millimeter has been explored in a severely limited way from the ground and, with partial elimination of atmospheric interference, from balloons. Important advantages can be gained with higher altitude platforms. Present efforts are confined to rockets and represent only first attempts at utilizing cryogenic systems in connection with cooled optics and sensors. Liquid helium temperatures are essential. Three to four years of experimentation scaled to Aerobee rocket capabilities is needed to solve instrumentation problems. Scaled-up versions may then follow (up to 30-inch telescopes) to be flown on larger rockets. It is not overly optimistic to expect many surprising discoveries in this broad spectral range (exploratory phase, $10M).

e. *Radio telescopes.*—Two categories of space radio telescopes are clearly needed. A long wavelength (a few MHz to a few hundred kHz) antenna, with a 20-kilometer aperture and 100 square degree beam width, is technologically feasible and could be implemented by 1970 (costing about $50M). For millimeter wave astronomy, the largest ground-based antenna now under construction is 30 feet in diameter. A 100-foot millimeter wave dish in low earth orbit appears to be a realizable goal by 1972–73 (cost about $50M).

This list of telescopes may well include examples which will be eliminated because of being shown by small-scale preliminary experiments to be insufficiently attractive. On the other hand, this list is quite likely incomplete since astronomical research outside the "optical" range (in its new wider sense) is only in its infancy. But in any case it is certain that several different types of telescopes are needed, carefully and systematically selected in sequence, to exploit fully the space opportunity for the study of the universe.

Each of these space telescopes has its independent value. But this value will be greatly enhanced by the existence of other space telescopes as well as vigorous ground based astronomical research—just as classical optical astronomy was decisively reinvigorated by the addition of radio astronomy.

Manned engineering operations may play a decisive role for the effective use of these space telescopes, and to that extent it appears economically essential that these telescopes be placed in similar, or at least osculating, orbits (though not necessarily close together in these orbits) so that the manned operations can utilize multipurpose manned vehicles, and possibly, in due course, a permanent space station. This similar-orbit condition does not appear at present to entail too severe a compromise with the primary missions of the individual telescopes, with the single exception of the very large antenna for radio astronomy which requires an extremely high orbit (say 2,000 miles or more). This collection of orbital instruments could then be serviced by trained engineer-astronauts who attend them intermittently.

Role of man.—The operation by man of an astronomical telescope falls into two distinct categories, scientific operations and engineering operations. The character of these two types of operations are quite different and will be considered separately.

a. *Scientific operations.*—Research utilizing a telescope consists typically of the cyclical repetition of three actions: data taking, data analysis, and contemplation about the scientific implications of the results. Only the first action involves the telescope, and this action typically takes no more than 10 percent of the researcher's time. Hence it takes a minimum of ten astronomers to utilize one telescope fully, say in rotation of 3 days each per month. Without this level of scientific manpower per telescope, the operation will rapidly deteriorate into pseudoscientific routine data taking, incongruent with the value of a large space telescope.

In view of the large number of scientists (plus their assistants) needed per telescope it appears evident that the scientific operation of a space telescope be conducted from the ground. Since true research is always at the limit of human ability, it appears vital that the impedance between the researcher and the space telescope be minimized; specifically, during periods of scientific operation the link between the researcher on the ground and the space telescope should be direct, i.e., not via a manned station, whenever practicable. This can be achieved either through the establishment of astronomical facilities in synchronous orbit or through a real time wide band communications satellite link between ground stations and low orbit spacecraft.

b. *Engineering operations.*—This category of operations consists of three types of actions: (1) putting a telescope into operation in orbit (which may range from the one extreme of standing by and physically contacting the telescope only in the case of failure to initiate operations from the ground, to the other extreme of actually assembling elements of the telescope in space), (2) maintaining the telescope at top effectiveness (including repair of failed parts as well as the correction of unexpected deterioration of thermal, mechanical, and electronic adjustments for which no automated readjustments were included in the original design), and (3) updating of subsystems to avoid early obsolescence in a rapidly evolving scientific and technological period (for example, by replacing outdated radiation sensors, electronic imaging devices and spectographs).

Only for the third type of engineering action does it appear definite at this time that man in orbit is required, and only then whenever such updating action is warranted in connection with a primary telescope of very large capital cost. For engineering actions of the first two types the same statement cannot be made with any similar certainty at this time. Spacecraft like Mariner and Surveyor may be estimated to have an overall reliability of the order of 50 percent at present. Some of the major instruments on OSO's have failed, and the first and until now only OAO has failed. Nevertheless, for the level of complexity of these instruments it seems plausible that the necessary degree of reliability for completely unmanned operations will be achieved without excessive increase in cost.

However, for the next generation of telescopes which will be both more complex and more demanding in the perfection of their adjustments, completely unmanned operations will likely require reliability engineering fully

as high as is presently practiced in manned missions with corresponding increases in the cost of the telescopes. Under these circumstances manned engineering operation of these next generation telescopes may well approach economic competitiveness assuming that man's ability at zero-g is not seriously degraded, at least in short duration flights. If this estimate proves correct, then the new telescopes will become critical training and test tools for the further development of our ability in accomplishing difficult manned engineering operations in space.

Three more comments are offered, all based on very limited engineering considerations and practically no relevant actual experience: (1) It is hard to envisage that any single engineering operation on one telescope (whichever of the three types of actions mentioned above may be involved) could require a period greatly exceeding 2 weeks. (2) Any one telescope should require manned engineering attention normally at most twice a year; a higher rate would indicate an uneconomically short mean life of the critical parts in the telescope. (A consequence of these two estimates is that any given space telescope is occupied by scientific operation from the ground for 90 percent of the time without any connection with men in space.) (3) The astro-engineer selected for the task of carrying out the engineering operations in space for a specific telescope will have to train himself for this task by participating in the assembling and testing of the telescope on the ground, involving probably a total time (not necessarily all at once) of the order of one year for the larger telescopes and of half this length for the simplest ones.

Organizational arrangements.—The program of large astronomical telescopes in earth orbit is in size and character so different from the corresponding earlier programs that certain new organizational arrangements seem to be required.

a. *NASA-university arrangements.*—To initiate a program of this size in which the investigation of the universe is the central theme, NASA will need the assurance of persistent strong interest and active cooperation of the astronomical community. Conversely, the astronomers, committed for many years to major efforts in this program before substantial scientific fruits can be expected, must have a reasonable assurance of a major role in the scientific direction of this program. The appropriate arrangements to fulfill these requirements are one of the topics which have been investigated by an ad hoc committee appointed by the NASA administrator and chaired by Professor Norman Ramsey. Accordingly, this arrangement will not be discussed further in this paper.

b. *Intra-NASA arrangements.*—The large orbiting telescopes program envisages an eventual decisive role for manned engineering operations in space. Thus, it requires a degree of intimacy of manned space operations and scientific engineering operations which has not been reached heretofore and for which the administrative structure of NASA is not optimized. This does not imply necessarily any change in the basic structure of NASA, but it does imply that the invention and initiation of new intra-NASA arrangements for the fulfillment of these requirements are a *sine qua non* of this program.

c. *International arrangements.*—The proposed large orbiting telescopes program may present an unusually happy opportunity for international co-operation. Two modes of such cooperation seem certainly practicable and effective. First, for any one telescope that is in orbit and securely in scientific operation, research proposals from foreign scientists can be invited, reviewed as to their practical feasibility with the telescope in question, and then incorporated into the observing schedule. This procedure follows the well established pattern of guest investigators at ground based observatories and insures that the full scientific credit for his research results goes to the foreign scientist. Second, for the multipurpose orbiting telescopes (such as the large optical telescope) foreign scientists or scientific institutions can be invited to propose and—after technical review—build novel auxiliary equipment (such as spectrometers, sensors of new levels of sensitivity, etc.) which then must be ferried to and installed at the telescope, with the understanding that the foreign investigator has first priority in the use of his new equipment but that in due course its use may be scheduled for other scientists as well, just as will be the case for all the other equipment on the telescope in question. This second mode has the particularly desirable feature that it gives foreign institutions the opportunity to participate in space instrument engineering at a scale appropriate for their resources and capabilities.

Relation to ground-based astronomy.—The space astronomy program described in the previous sections of this appendix can be expected to result in dramatic advances in man's knowledge of the universe primarily as a result of extending the regions of the electromagnetic-spectrum available to observation (as well as greatly improved definition and level of detectability). But observations in the visible and radio frequencies from ground installations will continue to provide the backbone of astronomical research because of the much lower cost, greater flexibility, convenience and availability of such instruments. The new discoveries made with space instrumentation can be expected to stimulate great interest in detailed studies with ground-based instrumentation of objects which are detectable from the ground but whose identification as objects of great significance is made in a space observation at a different frequency. The interplay between ground observations and the decisions on high priority programs for the space observatory will be essential to the effective use of the observatory.

Thus, the successful exploitation for scientific purposes of the space observatory depends upon effective support from ground-based instrumentation. In addition, the new observational capabilities of the space systems will surely arouse such intense interest in astronomical research—as a result of new discoveries—that needs for expanded scientific manpower and new ground-based observations should be anticipated.

The needs already recognized in the Whitford Study* will, therefore, receive additional justification if this space astronomy program is pursued.

*"Ground-Based Astronomy—A Ten Year Program" . . . a report prepared by the Panel on Astronomical Facilities for the Committee on Science and Public Policy of the National Academy of Sciences/National Research Council, 1964, A. E. Whitford, Chairman.

Appendix B. Evaluation of Biomedical Data from Manned Space Flight

Review of current status.—Members of the Panel were briefed by medical officers of the Office of Manned Space Flight and by astronauts who have had experience in prolonged flight and in extravehicular activity. Substantial problems have been inherent in the acquisition of most forms of biomedical data in the Mercury and Gemini programs. They must be viewed in the historical perspective of the newly developing field of bioinstrumentation over the last ten years. Whereas only qualitative measures of the simplest and even primitive kind were possible in the Mercury program, there have been growing skills and facilities in the course of the Gemini program that have taken years for NASA to develop. Nevertheless, much of the data available at this time remain qualitative in areas where quantitative information has become imperative, and measurements in certain fields highly important for man's qualification for interplanetary flights are still in the planning phase.

Problems of bioinstrumentation have impeded collection of information in such areas as metabolic rates in basal and active states in space flight, and in collection and preservation of blood, urine and feces for postflight analysis. Similarly, detailed analysis of cyclic aspects of sleep and wakefulness, and of central nervous activity accompanying focused attention during task performance, with assessment of attention span and the onset of fatigue and drowsiness, has been limited by availability of suitable biosensors. No evaluations have been possible of patterns of muscular activity and motor coordination in the unrestrained individual in space flight, either while pressure-suited in extravehicular activity or in the shirt-sleeve environments essential in prolonged flights. Cardiovascular evaluation in man has necessarily been without use of revealing (but potentially hazardous) sensors inserted directly into the heart or great vessels. This inability emphasizes the importance of supplementary information from comparable subhuman primate flights.

Moreover, inadequacies in our current state of knowledge needed for extrapolation to prolonged manned flight are exemplified by inherent variations between subjects, as well as by variations in conditions of different flights. Thus, in evaluation of metabolic changes attributable to space flight, weightlessness may be a significant variable alone, or in combination with such factors as an oxygen atmosphere, confinement, variable regimes of physical activity, and suited or shirt-sleeve environments. For these reasons, the number of subjects to be flown for adequate biomedical baselines should necessarily continue until appropriate consistency can be established.

Adequate pre- and post-flight baselines have been substantially lacking in earlier missions.

Evaluation of specific information from Gemini program.—Data gathered in later and longer Gemini flights have emphasized the need for substantially more information on cardiovascular, metabolic, endocrine, and central nervous systems. Very rapid heart rates during physical effort in EVA, even to the point of exhaustion, require evaluation of factors in space suit design, as well as assessment of maximum tolerable workloads. Although approximate mean metabolic rates have been derived from carbon dioxide absorption in the cabin life support system, nothing is known of actual metabolic rates in EVA. It is not clear what capability man has in EVA or free in a cabin environment for skilled movements either of the whole body or in instrumental manipulations. No controlled ergometric observations have been made in space flight, and although the evidence suggests that brief heavy work loads can be adequately met, the findings are equally suggestive of reduced capability in prolonged effort, both during and after flight. Calcium excretion from the skeleton has been at a level indicative of significant but not yet critical loss in the first 14 days of manned flight, without evidence of any remission toward the end of that period. Further observations beyond this period would be most important.

Difficulties of in-flight sampling of body fluids, such as blood and urine, have prevented adequate assessment of potentially important changes in diurnal cycling in many metabolic parameters, and have also prevented detection of the time course in appearance of these effects. A sharp sodium retention has been detected in the blood post-flight but nothing is known of conditions in-flight. Post-flight examinations have shown decreased plasma volume. The red cell volume increases post-flight, and the cells show increased fragility. There is a strong increment in new red blood cells for several weeks post-flight. Preliminary data indicate that excretion of corticosteroids, a measure of response to psychological stress, is consistently low during flight, but aldosterone excretion is sharply increased post-flight.

It was emphasized to the Panel that evaluation of such metabolic changes in-flight is a most challenging undertaking. Changes already detected require careful evaluation for man's qualification and support in prolonged flight. Moreover, individual differences detected in these and other physiological parameters have emphasized the importance of a numerically adequate series of subjects in estabishment of statistically valid norms in these responses.

Evaluation of states of sleep and wakefulness by electroencephalographic recording of brain waves has been performed in only one flight (GT–7), but has provided continuous measures of sleep, wakefulness, and focused attention for the first 55 hours of flight. In view of findings in this study of altered patterns in the awake state, possibly related to states of arousal, more extensive investigations of this type would be important in assessment of

normality of sleep-wakefulness cycles and the maintenance in prolonged flights of normally focused attention.

Subjective information on biomedical problems from astronauts in prolonged flight and EVA.—Fourteen days' exposure to weightlessness evoked from an astronaut the subjective reaction that man could continue to perform in space flight for an indefinite period. Sleep, however, was irregular, and depended on accumulated fatigue over several days, which was then followed by good sleep. He concluded that he would have slept better if there had been a watchkeeper guarding essential spacecraft functions. He experienced no disorientation from sudden head movements. Tumbling up to 10 degrees per second with spacecraft windows closed evoked no subjective reactions, and did not arouse the crew from sleep. Subjective assertions of well-being, however, obviously provide no objective criterion of many undesirable and potentially hazardous trends in physiological status, and have little or no predictive value.

It appears that shedding of the space suit in prolonged flights is a vital factor in prophylaxis of cardiovascular deconditioning and some hematological changes. Certainly, a shirt-sleeve environment is conducive to offsetting many effects of confinement and lack of exercise. There was agreement between astronauts that attention lapses readily when there are no imposed tasks, with actual sleep occurring readily in daylight, even when partly out of the spacecraft in EVA.

Problems of mobility in EVA were vividly recounted to the panel. The inflated Gemini EVA suit requires a 3.5 p.s.i. differential pressure, and assumes a position of leg and arm abduction. Force must be exerted to change limb position, and the force must be maintained to sustain the altered posture. These forces contribute to the workload on the astronaut, and to his exhaustion with prolonged effort. It is not clear, however, that this is the sole, or necessarily the main factor, in rapid breathing and heart action accompanying exercise in EVA. As a separate and not necessarily related factor, suit heating has also been a persistent problem in EVA.

Motor performance in EVA has manifested difficulties associated with stabilization of the body as a whole. Whereas simulated performance of such tasks as attaching a tether to the nose of the spacecraft was successfully performed in 25 seconds in aircraft in free fall, this maneuver took 30 minutes in EVA. It was suggested that these differences might relate to corrective maneuvers by the airplane pilot that integrated small errors in vehicle attitude, and that these did not occur in space. The astronaut experienced difficulty in sitting on the nose of the spacecraft, from which he constantly tended to float in a direction away from the earth. The need was strongly emphasized for mechanical means of orientation that would obviate the need by the worker in space to concern himself with body position. Lurching movements inside and outside the spacecraft would be hazardous, and emphasizes requirements for adequate hand holds.

No formal psychological assessments have been made of error rates in switch setting, etc., in long missions, but astronauts claim that these are low. Long series of digits associated with computer updates were successfully copied without evidence of defective attention span. On the other hand, it was pointed out that the severity of effort in EVA exercise was not realized by the subject until he stopped to rest, indicating a need for development of predictive techniques that would warn of undue physical effort. Fatigue associated with EVA exercise was described as severe enough to prevent a repetition of this effort within 24 hours. There was agreement that dryness of mouth and nose associated with the oxygen atmosphere was persistently disagreeable.

Proposed physiological and psychological investigations.—Future flights in the Saturn Apollo Applications Program will be heavily oriented toward acquisition of biomedical and behavioral data. These experimental requirements are described in Medical Aspects of an Orbiting Research Laboratory (NASA Document SP–86). It appears that although these experiments will comprehensively evaluate important metabolic requirements, other areas, such as cardiovascular and central nervous parameters, have received less detailed consideration. There are obvious safety factors which would limit deep instrumentation for these measurements in man, but for which subhuman primates would be well suited. Such animal measurements were specifically precluded as concomitants to measurements in man, but could be performed logically in conjunction with observations on man in a space station.

It was emphasized that before a major effort could be directed to a large space station, four major questions should be answered:

1. Is an artificial gravity necessary, and if so, by what means should this be secured?
2. What atmosphere should be provided, and what diluent gases should be provided in a mixed gas system?
3. What are the requirements for "comfortable living," particularly in relation to feeding and hygiene?
4. What are the optimal procedures for man's utilization in space as an observer, as a mechanic, and as a decisionmaker?

Derivation of laboratory environments from the current generation of space vehicles.—The specialized configurations that have evolved in the Apollo vehicles do not inherently suggest easy adaptation to laboratory needs for man's qualification for prolonged flight, including studies of group interactions in confined spaces. Neither the Command and Service Modules (CSM), nor the Lunar Module (LM) have large enough free volumes to be so used.

For these reasons, NASA has suggested development of the spent Saturn S–IVB stage as a test space. Access to the hydrogen tank would be gained from the CSM by a hatchway through the airlock section which joins them. The available volume would be approximately 10,000 cubic feet. Since no equipment, partitions, or other impedimenta can be installed in the tank prior to launch, astronauts would be required to take with them all apparatus and living needs. It would be necessary for the astronauts to actually build floors, sleeping areas, and other essential needs for habitability. The prime objectives of such missions would be biomedical, with evaluation of man's abilities in repair and maintenance.

In the light of recent experience in EVA, some doubts arise about man's ability to carry out extensive construction efforts in space without assistance yet to be determined, in his motor performances. Present NASA plans call for flights up to 28 days in the spent S–IVB stage. Later plans include consideration of means of orbiting an S–IVB stage already furnished as a laboratory. The requirements that man actually construct his laboratories in space in these initial applications may constitute a serious impediment to their development, despite advantages of a large available volume.

The Panel considered the possibility of alternate vehicles for biomedical qualification of man, particularly certain configurations of the USAF Manned Orbiting Laboratory. Available volumes would be greater than that in the Apollo CSM and LM modules (although substantially smaller than in the Saturn S–IVB), with the opportunity to test man for periods of 30 days or longer in a shirt-sleeve environment. Utility of this vehicle for biomedical qualification appears to rest on the date at which it might be available for detailed biomedical testing.

Biomedical investigations currently planned by the USAF in these flights would need to be substantially expanded to take their place in progressive qualification of man for interplanetary flight. It may be desirable for NASA to acquire MOL vehicles for its use in biomedical qualification, particularly if delivery schedules before 1970 are deemed realistic. The NASA proposal for utilization of the S–IVB stage is contingent on laboratory construction by man in space, without clear prior evidence of man's ability to perform such tasks. Even if successful, it is a paramount requirement that opportunities should not be lost to gather detailed biomedical data from carefully conceived experiments accompanying the construction procedures. Without such data, our ability to extrapolate further in man's qualification would not be materially assisted. For these reasons, the opportunity for a detailed and more gradual approach to increasing task requirements may lie in the maximum utilization of the MOL, where fully developed laboratory and living areas would allow adequate observations on man's physiological and psychological responses.

Appendix C. Review of the Apollo Telescope Mount for Solar Astronomy*

September 29, 1966, a subpanel of the Space Science Panel (Branscomb, Purcell, Schwarzschild, Chamberlain, Friedman, and Shapiro) met with NASA staff from Headquarters (Naugle, Forsythe, Disher, Rosen, and Taylor) and Marshall Space Flight Center (von Braun, Haeussermann, Stuhlinger, and Belew) to discuss the proposed 1968 solar astronomy mission in the Apollo Applications Program.

Subsequent to this meeting the mission plans have undergone substantial modification, but the discussion here will serve to illustrate the Joint Panels' viewpoint on the best way to carry out a manned supported project directed at a scientific objective.

The experiments for the Apollo Telescope Mount are upgraded versions of those originally planned for unmanned AOSO, which was terminated in January 1966. This includes a white light coronagraph, spectroheliographs covering ultraviolet and X-ray wavelengths, and scanning spectrographs covering the ultraviolet down to 800 A°. If guidance and stability requirements are met, these experiments have the capability of making far reaching contributions to our knowledge of the sun, particularly as regards solar activity (flares, spots, the structure and dynamics of the chromosphere and corona). They not only take advantage of wavelength ranges not accessible on earth but also are expected to benefit from low scattered light and high optical and spectroscopic resolution. The experiments will be of maximum value if conducted during a period of high solar activity, which is correlated with the period near sunspot maximum.

OSSA was conducting a study concurrently with the AOSO project on a concept called Apollo Telescope Mount (ATM) which was an instrument platform capable of accurate pointing at the sun and originally conceived as mounted on gimbals attached to the Apollo Service Module. The phrase ATM is now taken to mean any more generalized engineering concept which adapts astronomical instruments requiring accurate guidance to the man-operated Apollo spacecraft components.

When the decision to perform the AOSO experiments on the Apollo series was made, the experimenters began the process by redesign of their instruments to take advantage of photographic data recording and more ambitious specifications on pointing stability, drift rate, and absolute accuracy which are the objectives of the ATM. (Pitch and yaw excursions $\leqq \pm 2.5$ arc-sec. for 15 minutes time; pitch and yaw jitter $\leqq \pm 1$ arc sec./sec. of time; roll excursion 7.5 arc min. in 15 minutes, roll jitter $\leqq 1$ arc

*This review was based on the design proposed as of September 1966.

min./sec. of time, offset pointing at any point in a 20 arc-min. area including the solar disk, visually selected.)

These experiments, before they began the upgrading process for ATM, were scheduled for four AOSO missions between 1968 and 1970. The current NASA plan is to fly the AAP–ATM mission on uprated Saturn I vehicles (211 and 212) in November 1968—less than 2 years from now. It is acknowledged that the experimenters are extremely hard pressed to insure completion and test of the instruments to meet that schedule—especially the coronagraph and the X-ray objective-grating telescope. The Panel anticipates that it will become necessary to slip the launch date in order to maximize the probability of successful operation of the instruments. The reason given for the great pressure to achieve a November 1968 launch is the importance of flying the mission during the period of maximum solar activity. But this maximum normally covers a rather broad period of time. We think that in 1968–69 a class II flare will very likely be observable every couple of days; in 1970 their frequency is unlikely to be less than half this rate.

The engineering concept for conducting these experiments with the Apollo hardware is under intensive study at MSFC, and they were working toward a firm conclusion of their studies by November 1, 1966. They have examined and apparently rejected the original ATM concept of a gimballed platform on the Service Module on the grounds that: (*a*) the full volume of the Service Module is needed for life support supplies to extend the mission to 28 days; and (*b*), a mode which makes the ATM detachable from the CSM permits it to remain in orbit for possible re-use on a future mission.

A further constraint under which MSFC is working is the 24 months to scheduled launch and the fact that it will be at least 12 months before it is clear that the 211 hardware will not be needed for Apollo. Thus with the November 1968 launch date, extended modification of the Command Module is out of the question, since major changes would require extensive tests to verify its manned rating.

MSFC is still studying a mode in which the telescopes (which are all bore sighted on the same axis and occupy a cylindrical volume 5 feet in diameter by 10 feet long) are rigidly mounted to the adapter end of the Service Module, and the entire CSM is pointed at the sun. This avenue will surely be rejected, and indeed it was stated that the CSM will have to be gravity stabilized (thus always pointing along a radius of the earth) if it is to fly for 28 days.

OMSF has thus arrived at the following mode of operation: The CSM, equipped for a 28-day mission and containing three astronauts will be launched on Uprated Saturn I No. 211. Shortly after, it will rendezvous with a LM ascent stage launched unmanned into the same orbit on Uprated Saturn I No. 212. This LM has a rack rigidly affixed to the back

of it (in place of the descent and ascent motors) containing the cylindrical instrument package. The LM would then be occupied by two astronauts (possibly only one), probably entering it by EVA from the CM. Control moment gyros (CMG) which have been under development by Bendix for NASA-Langley would be used to stabilize and guide the LM, to meet the ±2.5 arc-second pitch and yaw attitude limits required for the instruments. The astronauts would be constrained to very slow movements of their limbs and would be strapped in place; even so, the CMG's will be the largest ever built (weighing 90 pounds, diameter 3 feet, angular speed 8,000 revolutions per minute).

The astronaut is required, on each sunlit portion of the orbit, to: (*a*) acquire the sun; (*b*) select the point on the sun to which the instruments are to be bore-sighted (using a video display of the sun in H alpha or X-ray light); (*c*) steer the axis to that point, select and operate the experiment in voice consultation with ground-based principal investigators. He must determine bore-sight errors in each instrument (which can easily exceed 2.5 arc-sec.) and be prepared to calculate offset corrections from his selected target for correct pointing of the spectrographs.* All the while he must remain in a state of very great alertness for a solar flare, which must be identified in the first minute or two and not missed, since only a few may occur during the flight.

At the conclusion of the mission (or during it, if film has been consumed) he must recover the exposed film—largely through EVA.

There remains the problem of station keeping, since the CSM has less drag than the LM. Although a tether between LM and CSM is under consideration it does not solve the station-keeping problem. The LM gas-jet altitude control system will probably be used to keep it near the CSM.

PANEL COMMENTS

It is clear to the Panel that from a conceptual point of view this is the wrong way to carry out a man-supported astronomy project in earth orbit, for the following reasons:

(*a*) Since the man's role (aside from final or occasional film recovery for which EVA is necessary) consists of operating levers, buttons, and switches on the basis of a video presentation of the solar disk and other electrical signal inputs, it makes no intrinsic difference whether he is 10 feet or 100 feet from the instruments and control systems which he manipulates through electrical signals. If he must be in orbit for other reasons, he should be outside the accurately pointed platform, thus enormously reducing the difficulty of achieving the pointing accuracy and enabling him to move about freely.

*NOTE.—At present no provision is made for designating the apparent orientation of the solar disk (e.g., the north solar pole). This will probably be essential and perhaps can be done by retention of the LM navigation equipment or by computation from the angle of the earth horizon at dawn.

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(*b*) The heaviest demands on the man are to do things which ideally should be done on the ground (the exercise of scientific judgment in choosing targets and experiments) or by electromechanical systems (for acquisition and pointing) which do not have to override the angular momentum of the man's movements.

(*c*) There is no time in the development of this project to design the scientific payload so that the man can contribute to its probability of successful operation through repair and maintenance—the one function for which a man in orbit may ultimately prove indispensable with systems as complex as these experiments.

We recognize that pending the installation of a broad band (a few megahertz) spacecraft-to-communications satellite worldwide net (i.e., early to middle 1970's), so that the same video images seen by the astronaut in the LM can be displayed on the ground to astronomers, the astronomer-in-orbit has the advantage of always having access to the instruments while on the sunlit side of the earth. Furthermore, he expects to be able to see a video presentation of the disk in X-rays, which may prove important in early flare detection. Thus the achievement of these experiments during solar maximum (i.e., before 1971) requires his presence in orbit, and capability to control the spacecraft.

It is exceedingly unfortunate that this time scale also precludes relocating the ATM and LM control panels into the CSM—operated through a microwave (or cable) link with the man in the CSM and the LM unoccupied. He could then accomplish virtually everything that would have been done in the LM, without constituting an enormous perturbation to the guidance and without introducing environmental contamination problems due to the necessity of life support on the LM.

Based on experience in ground-based observations, in which experienced astronomers engage in intensive observing programs on large and costly instruments through a period of several days (or nights) and find the mental concentration quite fatiguing, and adding to this special demands of looking for rare events with sudden onsets under conditions in which any sudden motion of the arm will throw the instruments off target, we are very pessimistic that astronaut performance in this demanding role will live up to expectation. NASA analysis of possible astronaut work schedules during a 28-day mission suggest that 100 hours of data on each of the six instruments will be possible. Since, in general, only one or two will be in operation simultaneously, this requires 5 to 6 hours of actual observing per day. We doubt very seriously that more than a fraction of this can be achieved over the 28-day period at a level of proficiency adequate for the scientific objectives.

However, we feel that it is more probable than not that sufficient data will be obtained to make a substantial scientific contribution. Although the expected value of scientific return may be no greater than would have been obtained with one of the original 9-month AOSO flights, we also recognize

that the basic flight hardware is already purchased and committed to Apollo if needed. Then the incremental cost for this mission is not much greater than the 36 million needed for the proposed ATM development.

We recommend that a 12-month delay in launch date (to about January 1970) be planned now. If this is sufficient to permit engineering of a mode which does not require the pointing of the man as well as the instruments, such a mode should be used; if not, the project should be encouraged to proceed in the LM. We would note that the proposed mode does not take us down the developmental path which we foresee for earth orbital astronomy (with an autonomous spacecraft accessible to manned maintenance from a nearby vehicle and scientific control from the ground). It will very likely demonstrate dramatically the disadvantages of overconstraining the man physically while overburdening him mentally and doing both over a 1-month period with relief only during periods of sleep. Thus, we urge that the mission be conducted primarily for the value of the scientific return and that all mission parameters be optimized to that objective.

In addition to the recommended 1-year postponement of the launch date, we also urge that careful attention be given to the schedules for completing the scientific experiments, so that additional funding may be made available to the principal investigators (P.I.'s), if this will relieve the time pressure or probability of failure.

Finally, discussions with Astronauts Gordon and Borman made clear the need for early and direct contact between P.I.'s and the mission astronaut. We urge that the P.I.'s and mission astronaut be put in contact with one another as soon as possible so that each can start on the complex problem of experiment management under flight conditions.

Appendix D. Objectives and Means in Lunar Surface Exploration

(A report by the Space Science and Space Vehicle Panels, October 15, 1963)

Introduction.—Although the basic general goal of the national space program is expansion of scientific knowledge through the exploration of the solar system, the priority objective in the overall program at the present time is landing men on the moon and returning them to earth safely. However, this objective may not be attained unless we obtain enough prior knowledge of the physical characteristics of the lunar surface to design systems which can land on, take off from, and explore the lunar surface safely. Such knowledge can be obtained from an appropriate combination of unmanned reconnaissance of the lunar surface by instruments placed in lunar orbit (Project Orbiter) and from photography and physical measurements of the lunar surface with hard- or soft-landing instrument packages (Projects Ranger and Surveyor).

Assuming that the Apollo mission is accomplished and men can land on the moon, the problem then arises as to how the skills we have developed can be used most effectively in manned exploration of the lunar surface for scientific purposes. There are questions of scientific interest which mainly concern the nature of the measurements and experiments to be performed, and of the kinds of instruments and facilities needed to complement the capabilities of the men placed on the moon. But more importantly for immediate planning, the Apollo systems being developed must provide enough lunar staytime and astronaut mobility to assure that useful experiments and observations can actually be accomplished when the time comes.

Finally, a thoughtfully conceived program for lunar exploration must allow for the contingency that its Apollo phase, primarily because of its great technological complexity and the associated problems of system reliability and crew safety, may eventually suffer substantial slippage in the currently planned dates of its accomplishment. In that case the Nation might be left for a time with no lunar program at all unless the planning includes the provision of a backup in the form of continued Surveyor-type missions beyond the dates now envisioned, and more advanced unmanned programs.

The principal purpose of this paper is to outline the Panels' views in these related connections. Clearly it is not the Panels' function to give detailed guidance as to the nature of particular experiments to be performed, or of the specific instrumentation to be employed. The Panels have sought, rather, to examine broadly some of the problems the Nation faces in lunar exploration, and to present summary judgments flowing from considerable study and discussion.

General scientific objectives on the lunar surface.—The moon is the closest astronomical object to the earth and we are committed to landing a man there and returning him safely to the earth in this decade. Although the first successful round trip will in itself be an extremely significant accomplishment as a demonstration of a very difficult technology, the question naturally arises as to why we are interested in the moon from a scientific standpoint, and what significance lunar exploration has beyond the satisfaction of the basic urge to take a closer look at the object which has hung in the skies for longer than man has lived on this planet.

The urge to visit it because it is there is surely a strong one but there are deeper reasons for doing so, and if manned lunar landings are to realize their full potential, the achievement of the presently foreseeable goals ought to be a central part of our planning. It is without doubt also true that new questions and new reasons for going there will develop as we get information back, so that the planning cannot be rigid; we must provide vehicles and tools with which we can simultaneously learn what is foreseeably profitable and explore what we do not yet understand. In order to see what such considerations really mean, we have attempted to evaluate possible scientific objectives in general terms.

The central problems around which scientific interest in the moon revolve concern its origin and history, and its relation to the earth and to the solar system. The moon is a relatively unspoiled body, its surface not having been subjected to the wear and tear of erosion by an atmosphere and water. Hence a study of its surface may tell us its history, its age, whether it was formed when the solar system was formed, whether at some time it separated from the earth or whether it was captured by the earth at some time in its history. Answers to these questions may profoundly affect our views of the evolution of the solar system and its place, as well as man's, in the larger scheme of things.

Naturally all of these problems must be approached indirectly through means such as the following:

a. From the gross chemical composition of the moon we can learn something of its relation to the chemical composition of the earth's crust, to that of the earth as a whole, or to meteorites.

b. From the abundance ratios of certain isotopes the time at which the material was formed can be determined. This technique may make it possible to determine the age of the moon as a whole and the age of various geological (or rather, selenological) features of the moon.

c. From the structure of the lunar surface and subsurface we may infer much concerning the conditions under which the moon was formed, e.g., as a solid body or by solidification from a melt. By noting the effect of bombardment both by meteorites and solar radiation in successive surface strata, we may be able to learn more of the history of the sun and the solar system.

d. By installing seismic instruments we may learn something of the interior structure of the moon.

What we know already is that the moon is a very curious body, quite unlike the earth. It is very much less dense and its surface characteristics, as determined optically and by radar reflections, are certainly very peculiar. What we would like to examine is how we can plan to learn the most from the first few expeditions to the moon, manned and unmanned.

Unmanned studies of the lunar surface prior to Apollo.—The problems of determining lunar surface characteristics well in advance of the first manned landing attempt and that of selecting the most suitable site for the first landing have been a major concern of the Space Vehicle and Space Science Panels for over a year. In October 1962, the Panels conducted their first review of the unmanned lunar exploration program at the Jet Propulsion Laboratory and followed this with meetings in February 1963 and June 1963 which were specifically aimed at evaluating the adequacy of the unmanned program to meet the requirements of Apollo. As a result of this relatively extensive review, the Panels have become convinced that the unmanned lunar exploration program is vital to the success of Apollo. This program is composed of three separate projects: Ranger, Surveyor (Lander), and (Lunar) Orbiter.

> The Ranger spacecraft is designed to make a hard landing on the moon, taking television pictures of the lunar surface during the landing approach. It is planned that later Rangers will be able to take seismic measurements or, perhaps, high resolution photographs of the surface. The next Ranger launch is scheduled for late in 1963.
>
> Surveyor is designed for a soft landing on the moon. It will take high resolution television pictures of the surface immediately surrounding the spacecraft, and measure surface bearing strength and composition. The first operational Surveyor flight is scheduled to take place in the latter half of 1965 (18 months later than the next Ranger), with 13 operational missions planned through mid 1967. Assuming no slippage of Surveyor relative to Apollo, all of these missions would be flown prior to the first manned landing. Unfortunately, the Surveyor is in a precarious situation in that its payload weight is so small that difficulties with either the Centaur rocket or the payload might eliminate all of its capabilities.
>
> Orbiter: This spacecraft complements Surveyor by orbiting the moon and photographing large surface areas. Surveyor landing locations can be located accurately on the Orbiter maps (this is not possible with the Ranger pictures), and the detailed information that Surveyor will provide about the small area in its immediate vicinity can be related to the much larger area of the Orbiter photographs. In addition, characteristics of the orbiter's lunar orbits will lead to a more

complete description of the moon's gravitational field. Detailed knowledge of this field will be useful to the LOR mode, particularly if lunar orbital operations extend over several days. Ten Orbiter flights are planned, their schedule generally coinciding with that of the operational Surveyors.

An important element of background to a discussion of the Panels' opinions about this program is the fact that so little is known about the characteristics of the moon's surface. Moreover, certain characteristics—such as its bearing strength, thickness of the dust layer, or surface roughness—may turn out to be such as to put severe restrictions on LEM design and on plans for the landing operation. Information about the lunar surface is thus required for two basic purposes directly related to Apollo engineering and operations:

a. First, so that the LEM may be properly designed for the surface conditions it may be expected to encounter. In general, design modifications must be introduced into the LEM design and fabrication process some 18 months prior to the first scheduled LEM flight. Early information is therefore important to insure minimum slippage of the manned landings due to unexpectedly severe surface conditions.

b. Second, so that landing sites may be selected which conform to the limitations of the then existing LEM design. At the time of the first landing, it is important that we understand what the probabilities are that the LEM will in fact find favorable landing conditions.

In evaluating the unmanned programs against this general background, we find that Ranger provides information much earlier although of more limited use than Surveyor and Orbiter. The television pictures will be of some usefulness to LEM design and will provide us with our first evidence about the general roughness of the lunar surface. These pictures of the lunar surface are expected to be obtained more than a year prior to the next available information from Surveyor. Early information about the lunar surface, even if it is relatively meager, becomes extremely important for long-range planning. In addition, later Rangers may be capable of measuring the bearing strength of the surface and of photographing it with a higher degree of resolution. This information would be very valuable since it may provide an important input to the LEM design at a comparatively early stage.

Surveyor and Orbiter may be considered a team, each program complementing the other. Together they apply themselves to these questions:

Do surface areas exist for which the present design criteria for the LEM are adequate?

Are there enough of these areas to give high confidence that the LEM will land in one?

If not, how should the LEM design be modified to provide this confidence?

Where should the first landing be attempted?

The Panels are convinced that these contributions from the unmanned program are essential to the success of Apollo systems. Because of the

Apollo mission's high national priority it would then seem evident that the lunar surface experiments planned for the first few Surveyors should be primarily for acquiring data directly relevant to the Apollo mission. Therefore, investigations of the lunar surface should be done with Surveyor with the aim of finding out as much as possible about the nature of that surface and its radiation and micrometeorite environment. Experiments unrelated to that problem should be given a lower priority and none of these should be included if there is a risk of their degrading the probability of success of the mission. The necessity for setting clear priorities will become especially great if the instrumentation payload of the Surveyor drops below its present 65 pounds either because of further difficulties with the Centaur or a weight increase of the Surveyor spacecraft.

Scientific efforts associated with the Apollo mission.—While it is appreciated that the manned landing in itself will be a magnificent feat, incomparably greater permanent value will come from using it as the first step in the systematic scientific study of the bodies of the solar system. The main justification for a manned landing has always been the great variety of tasks which can be skillfully performed by men who can use observations at every stage to adjust their actions for the next. Most scientists agree that the exploration of the moon is likely to be a sufficiently complex and varied job to utilize such an ability. In view of all this, insufficient attention to making full use of the Apollo mission for scientific purposes would come as a great disappointment to the scientific community and probably, in the long run, to world opinion. Much of the long-run prestige value of lunar exploration should devolve to the country making the most significant scientific contributions.

In light of the above, it is most important that a preliminary plan for the scientific exploration of the moon be set forth in detail. It is recognized that our present knowledge of the lunar environment is somewhat meager; nevertheless, there is enough information available on which to base a useful initial plan for scientific operations. Naturally, we must be prepared to modify the plan as new information about the moon comes in from Ranger, Surveyor, and Orbiter. The Panels believe that the existence of a detailed description of the activities to be performed beginning with the first Apollo landings will provide a structure within which the development of scientific and operational equipment can proceed in an orderly way, and against which new proposals for additional experiments or increased stay-time can be evaluated. Of perhaps more importance, such a plan would provide a specific proposal which could be evaluated, criticized, and improved as the technological situation becomes more firm and more information becomes available from Surveyor, Orbiter, and other unmanned programs. It is therefore recommended that NASA formulate a plan for scientific operations, to include the chronological sequence of actions of the astronaut and operations of the equipment and instruments to be used by him.

As a preface and background to such an operational plan, it is useful to discuss the Panels' opinions about the measurements which, in the light of present information about the moon's surface, seem to be necessary for dealing with a high proportion of the questions which can now be asked about the moon and its origin.

Lunar features to be investigated and measurements to be made.—The Panels feel that the most important investigations are those which will lead to an analysis of the age and composition of the major lunar surface features and to the structure of the moon as a whole. The plan for scientific operations should therefore provide for exploration of marial areas, continental areas, and post-marial craters. In each of these areas the following activities should be accomplished: (i) detailed photography, (ii) surface and subsurface sampling for return to earth, (iii) surface temperature measurements as a function of time, and depth, (iv) seismic measurements. As a first estimate, it seems reasonable to expect that these samples and data obtained from each of two or three continental areas, marial areas, and craters would provide a substantial portion of the total information that we can reasonably expect to get from the moon.

It is assumed that Lunar Orbiters will provide the best topographical maps of the surface and it does not seem fruitful to have the astronaut do more than a rough topographical sketch of the accessible area, but it will be very valuable for him to take high quality photographs of the topography and unusual surface features, and close-up photographs of the surface itself.

Mobility and instruments required.—In view of the difficulties that may be encountered in landing the LEM on a difficult surface, it seems reasonable to require the Apollo landing site to be on a marial surface. Since present estimates of Apollo landing dispersions are between three-quarters of a mile and 1 mile, it is likely that the landing site selected will be several miles from a continental area or crater, and it is therefore very unlikely that an astronaut on foot could explore any area except the mare. Even within this area, the limitations of the space suit and the difficulty of the terrain make it unlikely that he can venture very far from the LEM. This situation suggests the requirement for a lunar surface vehicle to extend the astronauts' travel beyond the 1-mile range. In addition, various studies of possible marial landing sites have shown that a number of sites can be selected for which at least two different surface features lie not more than 10 miles away. An extension of the astronauts' range to 10 or 15 miles therefore seems desirable, and is probably sufficient for the explorations described above.

Studies have indicated that a vehicle to provide such mobility would weigh from 1,500 to 2,000 pounds. A roving vehicle that can be checked out by remote control beforehand and that could meet the astronaut on the site could help assure the desired level of mobility; it could also leave the astronaut with a more satisfactory environmental system, if some of the temperature and life-support system for extended periods could be a part

of the vehicle instead of being part of the space suit. Without such a vehicle one would have to depend on the astronauts' walking ability which, in the present state of ignorance of the lunar surface, cannot be predicted at all.

In addition to a vehicle providing mobility for the astronauts there is also the possibility of utilizing an unmanned roving vehicle within sight of the astronauts and under their remote control. Such a vehicle might be of great utility if the lunar surface proved to be hazardous or difficult for a manned vehicle. It could provide the astronauts with "extended eyes" through a TV link and thus allow them to see in more detail, and from different angles, features of interest noticed from the spacecraft. It would also allow them to retrieve high quality photographs of such features as well as samples of surface material. It is possible that a vehicle used in this mode could be smaller and lighter than one used for the transportation of the men, and from the point of view of the general problem of engineering lunar-roving vehicles, it would be very advantageous to be able to watch its detailed performance on the lunar surface from the LEM and to observe for example, the tracks left by it for a judgment of the characteristics of the ground. A vehicle of this type might be useful, in any case, as a second line of defense, should circumstances appear which would make it unsafe for the astronauts to go any distance from the spacecraft.

Similarly, the instruments and equipment necessary to perform the experiments described for each landing site (for example, such as those described in Bellcomm report "Scientific Exploitation of the Moon", March 18, 1963) would weigh about 2,000 to 3,000 pounds. It is the Panel's opinion, therefore, that mobility and scientific logistic support of 3,500 to 5,000 pounds per manned Apollo mission is required to provide the material basis for a substantial portion of the scientific information desirable from manned lunar exploration. The present Apollo payload for scientific instruments is 215 pounds. It is obvious that this is altogether insufficient to provide sufficient mobility and an adequate scientific effort.

Length of stay.—A considerable part of the time spent on the lunar surface will necessarily be devoted to checkout and other preparations for the return journey. It is essential for the success of the scientific part of the mission that a definite margin of time be available beyond that necessary to prepare for the return flight. The amount of time needed cannot be defined at this time; there is clearly much to be done for whatever length of stay can be arranged. In the early landings it is expected that the astronauts will work under considerable difficulties and that otherwise quite simple actions will take a long time to perform. It is also expected that there will be a variety of unusual and puzzling phenomena for them to observe and understand; some of them quite possibly related to their safety on the lunar surface. An initial plan for only 6 working hours for one man seems marginal and there is a risk that unpredictable circumstances will cut such a small margin of time to nothing.

For the first two Apollo landings a useful working time of only 6 hours for one astronaut on the surface can be accepted, provided that his mobility in a space suit on the lunar surface is not too drastically restricted. He would spend this time in making those observations of the lunar surface required to increase the safety of further landings and for sample collection and detailed photography. The scientific value of these first observations is likely to be very great, for many puzzling features of the moon and quite possibly major questions regarding the origin of the solar system may be answered by the later detailed analysis of the first lunar material collected and brought back to earth.

For later flights a working time of several days is, however, needed to face the varied tasks of the more geographically extended and detailed explorations which have been described in the above paragraphs. Longer periods of stay would allow geological exploration of the vicinity of the landing site, more careful and varied sample collection, and more detailed investigation of the physical structure of the moon's surface. Also, a certain amount of drilling would be possible to obtain samples from shallow depth, and a search could be conducted for any natural holes or crevices which would facilitate the collection of subsurface samples. The placing of instruments for a local seismic survey is likely to fit into this phase of the work. On the whole, the Panels believe that a stay of about 5 days should be planned for landings after the first two or three. It seems reasonable to expect that about 1,500 pounds of expendables and life-support facilities would be sufficient to provide for the astronauts for this period of of time.

The Panels did not consider in detail the many other scientific activities that might conceivably be done from the lunar surface but which are not directly related to the study of the moon, since we believe that it is now too early to bring such activities into the detailed planning phase.

In summary, the Panel sees a necessity for about 7,000 pounds of logistic support for an Apollo landing to provide for mobility on the surface, scientific instrumentation, life-support facilities, and expendables necessary for adequate scientific exploitation of an Apollo mission. We cannot at the moment foresee the need for much larger payloads in support of the Apollo mission. Although we appreciate that such a need may arise later, there is insufficient knowledge available to warrant the planning now for greater support payloads than about 7,000 pounds or stay-times longer than about 7 days. We believe that it is too early to decide whether a lunar base for scientific purposes will ever be necessary, and planning in this direction should be deferred. Finally, the Panels see a requirement for a detailed operational plan for scientific operations. Of first priority is a plan for the first Apollo landings which will assure the proper utilization of the few hours available on the lunar surface. Of next importance is a plan for the Apollo landings extended by some type of lunar logistic system. Both plans should be formulated immediately although with the expectation that they

will be revised as information is developed by the unmanned flights and the first Apollo landings.

Vehicles for lunar logistic support.—NASA has conducted studies of three different types of potential lunar supply vehicles: (*a*) The Saturn IB with a high energy third stage which can soft land approximately 1,500 pounds, (*b*) the Saturn V with a new spacecraft and upper stages, in place of the Apollo spacecraft and service module, which could land roughly 25,000 pounds in a direct flight mode, and (*c*) the LEM truck concept in which the mission is flown as in the manned landing and is in fact manned to lunar orbit, but the ascent rocket and fuel of the LEM is replaced by 7,000 to 9,000 pounds of payload and the LEM is landed automatically.

The choice among these modes or among any of them and still other alternatives must be determined after detailed studies of the problem. Nevertheless, certain choices have already emerged.

The second alternative, a direct-flight vehicle, is probably most attractive technically and provides the largest payload, but it requires a larger new vehicle development by our already strained facilities. Moreover, it is not clear that the very large payload is urgently needed.

The third alternative, the LEM truck, is attractive in that the mission is flown as in the manned Apollo mission, so that most of the Apollo system is exercised, thereby contributing to the development of its overall reliability. It too requires the development of a new vehicle, although it would be fairly closely related to the LEM.

The possibility of using an automated LEM with minor modification, and a correspondingly reduced payload, has not yet been explored and the Panel suggests that its feasibility as a logistic vehicle be studied along with the other alternatives.

The Saturn IB system would be incapable of landing the larger roving vehicle and would require several flights to the same point to assemble adequate supplies for a longer stay. This poses further unanswered questions regarding the mating of the supplies on the lunar surface. Nevertheless, there are other important reasons for developing an upper stage for the Saturn IB plus a landing vehicle, and even 1,500 pounds of supplies would greatly enhance the capabilities of the manned landing attempt.

The Panels have not resolved these issues. It seems important though that the studies in NASA be continued and broadened, with a view to selecting an optimum lunar logistic vehicle in about 1 year.

Contribution to mission safety.—It is assumed, as has been described above, that the Surveyor Lander and Orbiter programs will check out landing sites suitable for the LEM. Such verification is essential for Apollo and these programs may prove to be adequate for this purpose. But it is also possible that Surveyor results will be inconclusive and will leave some doubt as to the suitability of the ground for a LEM landing. Also, completely independent of the problem of the lunar surface, it may be that at the time of the first scheduled landing, we will not consider the system reliability yet high enough to risk a man. Accordingly, it seems likely that when a manned landing is imminent it will seem urgent to land an unmanned vehicle first. This could be fulfilled by a lunar logistic vehicle if it were available in time for the first Apollo landing. On the other hand, it could equally well be accomplished by an automatic LEM vehicle, whereas from the standpoint of scientific exploration, logistic support is not required until perhaps the third Apollo flight. It is therefore the Panels' opinion that plans should be made now to provide for a completely automatic landing mode for the LEM spacecraft.

Follow-on to Surveyor.—One of the contingencies against which space program planning should provide some insurance is that of possible substantial slippage in present Apollo schedules. In view of the great complexity of the systems required for the mission, and the difficulties associated with such complexity in insuring a reasonable probability of crew survival, substantial slippage in current schedules should not be assumed as unlikely. Since the current unmanned lunar exploration program is clearly marginal as to landed payload capability, slippage of the Apollo schedule might leave the United States with no effective tools for lunar exploration until the very end of the current decade, or perhaps even later.

On the other hand, current Soviet booster capabilities suggest an ability to soft land payloads on the moon now which are significantly heavier than those of Surveyor, even if no further difficulties develop. Assuming that Soviet sophistication in space instrumentation is not greatly inferior to our own, prudence in national planning would suggest that we anticipate significant unmanned lunar scientific accomplishments by future Soviet flights.

The Panels see no way to optimize the course of the space program under these circumstances except by following the direct route of providing substantially larger spacecraft capabilities than the Surveyor for availability in the 1967–68 time period. The Panels are mindful of the additional costs that such a course would entail. On the other hand they are also conscious, and would like to emphasize, that investments of the magnitude involved in Apollo, primarily because of its great complexity and novelty, by no means guarantee success at the scheduled time. And this means that the same considerations of national interest and security which were responsible for the initiation of Apollo suggest that adequate hedges in the form of enhanced ability for unmanned exploration are needed to protect against the consequences of serious schedule slippage in the manned lunar landing program.

The Panels have considered in a preliminary way the alternative routes available for acquiring the capability to launch payloads significantly more useful than those possible with the Centaur. An instrumentation payload of several hundred pounds on the lunar surface, perhaps as large as ten times that of the Surveyor, can probably be provided soonest by using either the Titan IIIC or a Saturn I-Agena D. If this course is followed no new vehicle development will be necessary, although the Agena has not yet been mated to the Saturn I. In either case, the present Surveyor (but carrying its full payload of 300 pounds) could be mated to the vehicle and a new spacecraft development would not be required.

On the other hand, the development of a third stage for the Saturn IB would enable a lunar soft landing of some 1,500 pounds of useful payload, provide early and relatively inexpensive capability for reentry testing of the Apollo heat shield, and lead to a Voyager (spacecraft for unmanned planetary exploration) payload substantially larger than that possible with the Titan IIIC or the Saturn I-Agena. Furthermore, the Saturn IB soft-landed lunar payload is large enough to make it perhaps competitive (on a per pound cost basis) with the LEM truck for use as the vehicle for lunar logistic support. A detailed comparison of schedules, costs, and reliabilities of Surveyor (or its improved successors) with Titan III, Saturn I-Agena, and the Saturn IB with a new upper stage, should be made as soon as possible with a view to selecting a system for this program.

Conclusions.—The major conclusions of the Panels' reviews of the objectives, and of the proposed means, for lunar surface exploration may thus be briefly summarized as follows:

(1) The Ranger and Surveyor programs are an essential component of the work which must be done in advance of Apollo to help assure that mission's success. This means that technical management and funding of these programs must be fully integrated with those for Apollo. In particular, the Panels believe that instrumentation payloads for Surveyor must be planned so that the first few successful missions provide data essential for Apollo engineering, and that these missions should have the same priority as any phase of the Apollo program proper.

(2) The payload marginality of the current Surveyor system, as well as the possibility that the Apollo schedule may slip substantially have strongly suggested to the Panels the importance of initiating a follow-on program to Surveyor, providing substantially larger payloads to be available not later than the 1967–68 time period. In view of the magnitude of the prospective investment in Apollo, the Panels' view is that such a program is not only reasonable in itself, but is an important hedge against not too improbable contingencies. The Panels therefore recommend the initiation of a follow-on Surveyor program after a detailed analysis of the relative advantages of alternative systems using Saturn IB, Saturn I, or Titan IIIC. In view of the possibility that even the present (65 pound) Surveyor payload may be too large for the Centaur, it may be wisest to make this vehicle choice largely on the basis of earliest availability.

(3) In order to provide for an unmanned landing of the LEM, in case initial system reliabilities or uncertainties about the lunar surface make the risk too great to use a man, plans should be made now to provide the LEM vehicle with a fully automatic landing mode of operation.

(4) After the major gains of the first one or two flights, the usefulness of the present Apollo system alone for scientific exploration of the moon is marginal, primarily because of extremely limited stay-time and inadequate

payload weight for instrumentation. It is important to correct this inadequacy by initiation of a lunar logistic support system for Apollo on a time schedule which will allow logistic support to accompany the third Apollo landing. A logistic support system adequate for reasonable, and foreseeable, crew survival and scientific needs should have a total soft-landed payload for each Apollo landing in the range of about 7,000 pounds. The Panels would assign to whatever system is selected as most reliable and economical a priority equal to that now possessed by Apollo.

(5) NASA should prepare a detailed operational plan for astronaut activities on the lunar surface, so that there will be adequate time for this plan to be perfected in consultation with the scientific community concerned.

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Appendix E. The Apollo Program

(A report by the Space Technology Panel, January 10, 1966)

Charge to the Panel.—The Panel was requested by Dr. D. F. Hornig to review the status of the Manned Lunar Landing Program, placing particular emphasis on an evaluation of prospects for the program's success on the currently approved time schedule. In view of the high national priority enjoyed by Apollo, the Panel was also asked to conduct its review in sufficient depth to develop recommendations whose implementation would tend to help ensure success within the current funding and schedule plans for the program.

Background.—The Apollo Program was established in May 1961 with the objective of a manned lunar landing and return mission in "this decade." NASA studies conducted during 1961–62 led to the selection of the Saturn V as the rocket to be employed in a mission plan (LOR) based on placing a multimodule spacecraft in a lunar orbit, using one of the modules (LEM) for descent to and ascent from the lunar surface, and culminating in a lunar orbit rendezvous of the LEM and of the earth return module (CSM) for crew transfer. Systems development along these lines was placed on a formal schedule basis about July 1962 after extensive discussions within the Government of NASA's choice of the LOR mission plan and of the associated cost, schedule, and probability of mission success estimates.

The Apollo Program is managed from NASA Headquarters in Washington, D.C., by the Director of Manned Space Flight who is an Associate Administrator of NASA (Dr. George Mueller), and by a Director of the Apollo Program who reports directly to him. The Apollo Program Director (Maj. Gen. Samuel Phillips) has a supporting staff in Washington and Program offices at each of the NASA Centers involved in the program. All hardware contracting for Apollo is handled through the Apollo Program offices.

The NASA Centers to which the technical execution of the program has been delegated by the Director of Manned Space Flight at NASA Headquarters in Washington are: The Marshall Space Flight Center (MSFC) in Huntsville, Ala., responsible for the Saturn V rocket; the Manned Spacecraft Center (MSC) in Houston, Tex., responsible for the Apollo spacecraft (CSM and LEM) and for the conduct of mission operations; and the Kennedy Space Center (KSC) at Cape Kennedy, Fla., responsible for the assembly, checkout, and launch of the combined Saturn V/Apollo Spacecraft System.

The main contractors for the Apollo Program were chosen to be: North American Aviation (NAA) at Downey, Calif., which is responsible for the

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Command and Service Modules (CSM) of the Apollo spacecraft and for the S–II stage of the Saturn V rocket; the Grumman Aircraft Engineering Corp., of Bethpage, Long Island, which is responsible for the Lunar Excursion Module (LEM); the Boeing Aircraft Corp. of Seattle, Wash., responsible for the first stage (S–IC) of the Saturn V as well as for integration of the three stages of this vehicle; and the Douglas Aircraft Corp. of Long Beach, Calif., responsible for the third stage (S–IVB) of the Saturn V.

Summary Description of the Panel's Review

(a) *Acquisition of consultants.*—In view of the emphasis in the Panel's assignment on evaluation of the mission's prospects for success, it was fortunate to secure the assistance of two experts with particularly broad and relevant experience in the engineering of complex systems with high reliability requirements. Dr. Hendrik Bode, of the Bell Telephone Laboratories, and Dr. Richard Kershner, of the Applied Physics Laboratory of Johns Hopkins University, participated actively in all aspects of the Panel's work.

(b) *Procedure.*—NASA was requested to provide briefings, generally in direct response to specific inquiries from the Panel. In addition, for each meeting the appropriate contractor and/or NASA Center provided written answers to written questions which the Panel had previously referred to the Appolo Program Director. In toto, the briefings and the questions/answers encompassed every main subsystem and operational phase of the mission. In addition, four Subpanels were organized to examine several areas in greater depth than was possible for the entire Panel to attempt at its more formally conducted meetings. Drs. Carlson, Donovan, Lees, and Rosser chaired Subpanels concerned, respectively, with: Space Suits and the Environmental Control System; Propulsion Subsystems (S–V and Apollo Spacecraft); Heat Shield and Reentry Tests; Modeling and Satistical Problems in Reliability Analyses and Predictions. In general, Subpanel memberships included special consultants in addition to Panel members, and meetings were arranged to provide both detailed briefings on particular developmental problem areas and further answers to specific questions posed by Subpanel chairmen in advance of each meeting. Reports were prepared by each of the Subpanels, reviewed in detail by the Panel in executive sessions, and constitute part of the basis for the Panel conclusions and recommendations contained in this report.

The Panel's review involved six meetings for a total of 13 working days at six locations: two 2-day meetings were held at contractor's plants (NAA and Grumman) and focused on the CSM and S–II stage at NAA, and on the LEM at Grumman; a 2-day meeting at MSFC, concerned mainly with development problems of the S–IC and S–IVB stages, and of the instrumentation unit (which guides and controls the vehicle until it is established in earth orbit); a 2-day session in Washington to review NASA Headquarters' operations in overall management of the program, and the work of A.T. & T.'s Bellcomm Corp. which supplies scientific and systems engineering support to the Office of Manned Space Flight; a 2-day meeting at KSC to review hardware development and operational problems in overall system assembly, checkout, and launch; and a 3-day meeting at MSC to review plans for overall mission planning and operations, for general discussions with Center directors and top program officials from NASA Headquarters, and for the Panel's final executive session.

The Panel received splendid cooperation from NASA Headquarters as well as from the Centers. It is clear that every effort was made by the responsible NASA officials to provide the Panel responsively with information at briefings, answers to questions, and with administrative support as required. These efforts were uniformly well executed with results fully satisfactory to the Panel.

(c) *Scope of report.*—The Apollo program presents major managerial problems and technological obstacles of unprecedented scope, complexity and difficulty. Accordingly, no review of the kind described above conducted by an outside group, no matter how qualified or industrious its members might be, could do substantially more than identify and review the major technical problems and the principal organizational, management and policy issues. For this reason, the Panel's approach in summarizing the results of its work, is to limit its comments only to a relatively small number of general questions. Similarly it has limited its recommendations to those which in its judgment are adequately supported by the evidence and analyses which it had been possible to consider during the review.

Principal Conclusions

(a) *Overall program status.*—The Panel finds that the Apollo program is based on a workable concept, that the present top management is effectively directing its attention to the right problems, and that implementation through NASA in general appears to be appropriately diligent and thorough. Technical program management at both the Headquarters and Center levels appears to be generally of a high order.

In the area of the industrial effort the Panel found the quality of the technical work to be acceptably good with minor exceptions noted in the Subcommittee reports. Systematic use is being made by all concerned of experience from prior relevant programs.

A program of the complexity of Apollo puts severe demands on technical manpower and perhaps inevitably the program is somewhat thinly supplied with engineering talent of top ability. In this connection the Panel notes that the CSM and LEM developments follow substantially behind those for the S–IB and S–V. Thus peak demands for technical manpower will occur later at MSC and KSC than at MSFC. It may therefore be possible to use qualified MSFC personnel for assistance on some of the development and testing programs at Houston and Cape Kennedy. A related point concerns the desirability of augmenting the staff of the Program Director where, in the Panel's judgment, a few more people of high technical and managerial competence could give considerable help to the current good but small group.

Turning to the specifics of the Apollo mission, the Panel sees no scientific or technical obstacles which cannot be overcome, and believes that the program as now conceived and managed will lead to a successful manned lunar landing and safe return.

An informal comparision of individual assessments by Panel members of the likely first date of mission success disclosed a majority view that this date will come before the end of 1969. Individual estimates range from mid-1968 to late-1971. However, the Panel is acutely aware that such judgments are being made on the results of subsystem tests, simulation studies, etc., which to date have been conducted almost entirely in ground facilities; and that a substantial extrapolation in judgment is needed to go from such data to an estimate of calendar date for mission success.

It appears to the Panel that adequate steps have been taken to make it unlikely that the Apollo program will have major design or engineering errors, but as development and flight tests proceed, it is characteristic of such programs that numerous detailed problems arise and the possibility of a major problem cannot be ruled out at this time.

The Panel notes that NASA programing appears to have provided an appropriate supply of extra vehicles to handle contingencies, and urges that this programing not be disturbed.

(b) *Reliability engineering and testing.*—It appears reasonably clear that the complete Apollo system will be available for lunar landing attempts on about the presently published NASA schedule. The question of prospects for success, therefore, reduces to that of proper functioning of this equipment throughout the mission to lunar landing and safe return to earth.

The assurance of proper functioning of the system is intended to be sufficiently high so that (*a*) a completely successful mission is likely to be accomplished within a very few attempts, and (*b*) the likelihood is very high that unsuccessful attempts do not involve astronaut fatalities.

NASA has established specific quantitative goals for the probability of success; namely, 0.90 for the probability of completely successful accomplishment of the mission, and 0.999 for the probability of crew survival. In view of the vast number of subsystems involved, when these reliability requirements are apportioned down to a lower level, the reliability specified for devices at about the component level frequently runs to 0.9999999.

Achievement of such assurance of proper functioning for complex technological systems generally depends on a thorough understanding of the scientific principles and operating characteristics of all its component parts and the interaction of these parts with each other and their environments. This understanding requires knowledge of the environment and meticulous detailing of the physical processes in all parts of the mechanism; and the eventual equipment and operation designs should be such that all modes of failure are eliminated entirely, or are circumvented by redundancy, or are

suppressed in likelihood of occurrence to an acceptable level. The design effort on Apollo includes explicit attention to these considerations.

Testing of various sorts is required; experimentation, to establish the necessary understanding of the principles and operating characteristics involved; qualification testing, to provide an objective measure of the success of the design work; and demonstration testing, where feasible, to provide statistical evidence concerning reliability.

Configuration control, quality control, procedural discipline, and software verification must all be applied appropriately to maximize the assurance that the systems to be flown correspond to those tested and will be operated in the manner planned.

For some equipment, for example, small electronic and mechanical components and standard assemblies of the same, sufficient testing information may exist or be obtainable to provide a statistically adequate demonstration of the desired reliability. Of course, it should also be noted that even in equipment composed of well documented components there can be difficulties in assessing the reliability of assemblages. If the assemblage is not one for which there exists well documented statistical information the difficulty is obvious. Even in the contrary case, when redundancy is required to meet the specification (which is almost always the case for the kinds of numbers demanded in the Apollo program) true and complete independence of redundant systems must be assured if one is to be confident that a new class of failure has not been introduced. Such complete independence is not always attained.

For many of the important parts of the Apollo system, demonstration testing of sufficient scope to provide statistically significant evaluation of reliability which approaches at all closely the assigned goals is simply out of the question because of the time and money that would be required for such determinations (e.g., the LEM ascent engine). In these cases, and, inevitably, for major subsystems and the Apollo assembly as a whole, the appropriate course of action is to deemphasize repetitive demonstration testing and emphasize instead a thorough program of carefully instrumented experimental testing (including testing over a range of operating and environmental conditions around and beyond the nominal) to enhance fundamental understanding of the apparatus, to disclose unsuspected modes of failure, and to give confidence that adequate margins of safety exist.

For most components of the Apollo system assurance of a high order of reliability must primarily rest on an appreciation of the status of the equipment as regards elimination, circumvention, or suppression of failure modes; and this appreciation, derived from careful analysis, experimental testing designed to develop understanding, and limited demonstration testing, will not be expressible in quantitative terms. Therefore, judgments of readiness for manned lunar landing attempts, or appraisals of success prospects, will not be supportable by quantitative reliability statements. Furthermore, attempts to translate sketchy statistics from testing experience into quantitative assessments of success prospects, while tempting, can be hazardously misleading.

NASA has procedures, focused in a program conducted by the General Electric Co., for centrally collecting design and test data, using them in a consistent way to make judgments through which each component is assigned a reliability number and then inserting these numbers into a mathematical model of system reliability. If the component reliabilities could be determined in the classical sense from statistically adequate tests, the use of such a math model would be justified without question. Since in most cases they cannot, no valid mathematically defined measure is available to determine how much money and time should reasonably be allotted to a given part to build up assurance of its proper functioning. The key element for decision appears to be engineering judgment. Application of the math model is an attempt to quantify the judgment. When feasible such quantification is desirable in itself. Furthermore, the math model can be of real assistance in helping to establish consistent standards and analyses throughout the widespread Apollo program. The danger is that with employment of unsound or uncertain numerical data as inputs the use of the quantitative outputs from the math model could lead to erroneous judgments as to the actual state of affairs. Nevertheless, in the absence of other means, this effort has served to establish a disciplined point of departure in judging a suitable distribution of effort toward reliability assurance; but is now perhaps in need of redirection or supplementation.

The program of quantitative reliability evaluation should, of course, be continued for all parts of the system for which defensible statistical distribution functions and useful quantities of test data are available; these partial quantitative characterizations of system reliability can usefully narrow the range of doubt about mission readiness that must inevitably be spanned by judgment. Furthermore, the need for consistent analysis procedures will remain and will probably be assisted by use of the math model. But to the extent that this approach encourages unsupported "numerology" and distracts management from the necessary scientific and engineering analyses it is a weakness, not a strength. It is the impression of the Panel that the top management personnel in NASA Headquarters and the Centers are fully aware of the potential weaknesses in the "math model" approach to reliability assurance and are using it with judicious care, but that they need to expand their efforts to spread this understanding to the lower levels and to the contractors.

There is a real need for an additional, different kind of appraising and evaluating function: that of determining the adequacy of understanding of the equipment and the light cast on it by experimental testing. It is particularly important that this need be filled now and be done in a systematic way. This task, which would focus on physical processes and properties rather than mathematical statistics, would involve staffing and functions rather different from those now under contract; and, in the view of the

Panel, a central appraisal function along these lines should be promptly instituted.

Assuming NASA can reorient or supplement the testing to increase understanding of the system and can organize to obtain objective evaluations of the degree of understanding, the Panel believes the prospects for program success will be acceptable.

(c) *Operations near and on the moon.*—Generally speaking, the Panel has been impressed with the depth of operational detail to which mission planning has been carried out. However, the Panel believes that for mission phases in lunar orbit, and for lunar landing and return, such planning has thus far not been as thorough as for other phases. This may largely be due to the fact that LEM is the principal vehicle in these phases and its development and testing is lagging the remainder of the Apollo spacecraft by perhaps a year.

In the Panel's judgment, the greatest uncertainties in the assurance of mission success and crew safety are to be found in mission phases near and on the moon. This is because—

(1) Our experience with men and hardware in space to date is only in earth orbit.
(2) The most critical operations affecting crew safety will involve coordinated operations in space of the separated CSM and LEM.
(3) The space and operational environments near and on the moon will not be as clearly understood as for other mission phases until after the Apollo mission has been successfully executed.

In view of such considerations the Panel believes it essential that mission planning for phases in lunar orbit and between it and the moon's surface be completed in detail as soon as possible. Until such plans are available, it will not be possible to define completely the simulated environments for LEM subsystems testing and for CSM/LEM interaction tests; and these unknowns will cloud appraisals of prospects for mission success.

The Panel notes that NASA is now planning use of earth-based data to assist in LEM–CSM rendezvous. We agree with this approach and encourage further attention to alternate modes of operation, to employment of earth-based data, spacecraft data, and appropriate combinations to maximize the ability to work around subsystem failures.

(d) *Unmanned LEM.*—The Panel discussed at considerable length whether an unmanned landing and takeoff should be made with the LEM prior to the first manned landing attempt. A critical factor in this discussion is the degree of success one assumes for Surveyor in evaluating the characteristics of the lunar surface environment. It appears to the Panel that the NASA technical management is now assuming—

(1) Surveyor will provide adequate data on the lunar surface environment, and
(2) with the data from Surveyor, it will be possible to simulate satisfactorily on earth, or with the LEM in earth orbit, all environ-

mental factors necessary to demonstrate the adequacy of the LEM and CSM.

Under these assumptions, the NASA view that the crew will contribute materially to the probability of successful LEM lunar touchdown and takeoff, and increase the overall probability of mission success, may well be correct. On the other hand, the Panel is concerned about possibilities that—

—Surveyor may fail to produce adequate or timely data, or

—the data obtained may raise serious questions as to the ability of the LEM to operate satisfactorily in the lunar surface environment.

In either of these circumstances a modified Apollo mission which culminated in an appropriately instrumented unmanned LEM lunar landing (done with study of the results by the crew of the CSM) could play an important role in demonstrating the feasibility of a safe manned lunar landing. The Panel is concerned that the NASA program does not now provide adequately for an unmanned LEM lunar landing and takeoff demonstration should it develop that such is desirable.

The Panel, therefore, believes that NASA should formulate and carry out a plan directed at making an unmanned lunar landing LEM capability available in a timely manner should it be necessary. Such a program of design studies, development of components, procurement, etc., should be set in motion, with implementing actions taken progressively over time in such a manner that the overall mission schedule is not seriously delayed by a firm determination at a later date to actually undertake an unmanned LEM mission.

The Panel believes that Apollo mission plans should call for minimal crew activity on the lunar surface during the first attempt, whether or not an unmanned LEM mission is incorporated into the program. This observation is intended to emphasize the Panel's views that the lunar environment and interactions of systems with it, provide the major uncertainties for mission planning and execution. In particular the space suit may provide inadequate reserve capability and what is available may preferably be reserved for coping with emergencies. A plan for minimal external crew activity on the first attempt would leave the crew with the maximum possible time available to cope with emergencies. To accomplish this requires that both the development engineers' and crew members' enthusiasm and self-confidence must be explicitly guarded against.

(e) *Technological approach.*—Much of the Panel's effort was directed to reviews of critical developmental problems in all the major hardware areas. While numerous developmental difficulties were reported, all appeared subject to elimination through appropriate effort and with relatively modest advances in the applicable technology. Among the more significant problems being given attention are those with space suits, with rocket engines in reaction control systems, with the nonredundant propulsion plants in the CSM and the LEM, and with the guidance and navigation systems. In a number of areas the Panel observed that the subcontractors were engaged in development programs which gave inadequate attention to the understanding of the physics of the items involved, and, correspondingly, to improvements in the applicable technology. As noted in the section on Reliability Engineering and Testing, a major part of the decision to proceed with the mission must depend upon an adequate technological understanding of the equipment. Therefore, the Panel believes it is important that all work statements, including those for the principal subcontractors, provide for carrying out the necessary technological effort to understand their hardware and to advance the state of the art wherever it is necessary to do so. Demonstration that the hardware meets performance specifications alone is insufficient. The testing program should insofar as possible also demonstrate an understanding of the physical principles underlying the design, operation, and application of the equipment.

(f) *Automated checkout.*—The complexity of the S–V/Apollo spacecraft system is so great that there is no reasonable alternative to fully automated checkout at Cape Kennedy prior to launch. Many thousands of measurements and functional checks will need to be programed and interpreted within a relatively short period after the system is fully assembled and prepared for launch. It is obvious that the sensor systems, the computers and the computer programs needed for such checkouts must be as thoroughly developed, tested, and debugged as the flight hardware itself. If this is not satisfactorily accomplished it is entirely possible that the checkout process can actually degrade the probability of mission success. The Panel believes that this area of responsibility, assigned to the Kennedy Space Center, is among the most critical in assuring the probability of mission success and the integrity of current mission schedules. It is not persuaded, however, that this program has been receiving the same depth of reliability and failure mode analysis as have the other "hardware" components of the program. There is some danger that the basically service character of these contributions of the checkout activities to the program may obscure the essentiality of their role.

(g) *The "computer software" problem.*—The Apollo program requires an enormous computer supported effort during hardware development, subsystem and system checkout at various stages of this development prior to launch, and, most importantly, during mission operations. It is obvious that some of the most complex computer programing yet devised will be required for this program. It is also well known that assuring the accuracy of complex computer programs can be an exceedingly difficult and time-consuming task. The current NASA effort for computer software support now runs in excess of $100 million annually. The Panel believes that the complexity, magnitude, and critical importance of this work warrants a "reliability assurance" program no less intensive than for direct mission hardware. Furthermore, the Panel feels that "reliability assessment" of software products by a group of experts not involved in their development is not only practical but may be the only effective way to insure timely discovery of errors.

Principal recommendations.—Although most of the Panel's recommendations are clearly implied by the conclusions discussed above, it is useful to state some of them explicitly in summary form.

(a) *Test programs and staff support directed at understanding.*—For many important parts of the Apollo system, demonstration testing of suffcient scope to provide statistically significant reliability data is simply out of the question because of the time and money that would be required for such determinations. In these cases, and inevitably, for major subsystems and the Apollo assembly as a whole, the Panel recommends that increased emphasis be placed on a thorough program of carefully instrumented experimental testing (including testing over a range of operating and environmental conditions beyond the nominal) to enhance fundamental understanding of the apparatus and to disclose clues to possible modes of failure and margins of safety provided.

Adequate monitoring of these may require expanded staff under the Program Director with talents considerably different from those needed for conventional reliability analysis.

(b) *Quantitative reliability appraisal.*—The conventional numerical approach to quantitative reliability appraisal has real utility in various parts of the Apollo program but at the same time offers some dangerous opportunities for misuse and misunderstanding. The Panel therefore urges a continuation and acceleration of current efforts by NASA Headquarters to disseminate to Centers and contractors a full appreciation of both the uses and the limitations of this approach.

(c) *Operations on the lunar surface.*—In view of the environmental uncertainties and the possible need for strenuous emergency activity, it is recommended that firm restraint be applied in formulating plans for crew activity on the lunar surface during the first attempt.

(d) *Planning for missions near and on the moon.*—The Panel believes that it is essential that mission planning for operation in lunar orbit and between it and the moon's surface be carried out in detail as soon as possible. The Panel is encouraged by the NASA planned use of earth-based operations to assist in LEM–CSM rendezvous and recommends exploration of other alternate modes of operation employing earth-based data, spacecraft data, and appropriate combinations to maximize the ability to work around subsystem failures; this is an excellent example of the kind of redundancy (using alternative systems based on different physical principles) that will enhance success prospects in the face of unexpected difficulties.

(e) *Unmanned LEM.*—The Panel recommends that NASA formulate and carry out a detailed plan directed at making an unmanned lunar landing LEM capability available in a timely manner should it prove necessary. The program should provide for design studies, development of components, procurement, etc., with time-phased decision points established so that the degree of implementation will protect the mission schedule against serious delay if a decision is made at a later date to carry out an unmanned LEM experiment.

(f) *Automated checkout.*—The Panel recommends that the automated checkout system receive the same depth of failure-mode analysis and be given the same level of testing to demonstrate understanding as the hardware components of the program.

(g) *Computer software.*—The Panel recommends that the Apollo program management provide for an appraisal and verification of the computer programs and software by a group separate and distinct from the one that generated them.

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