Document 9

Title: Special Committee on Space Technology, "Recommendations to the NASA Regarding a National Civil Space Program," October 28, 1958.

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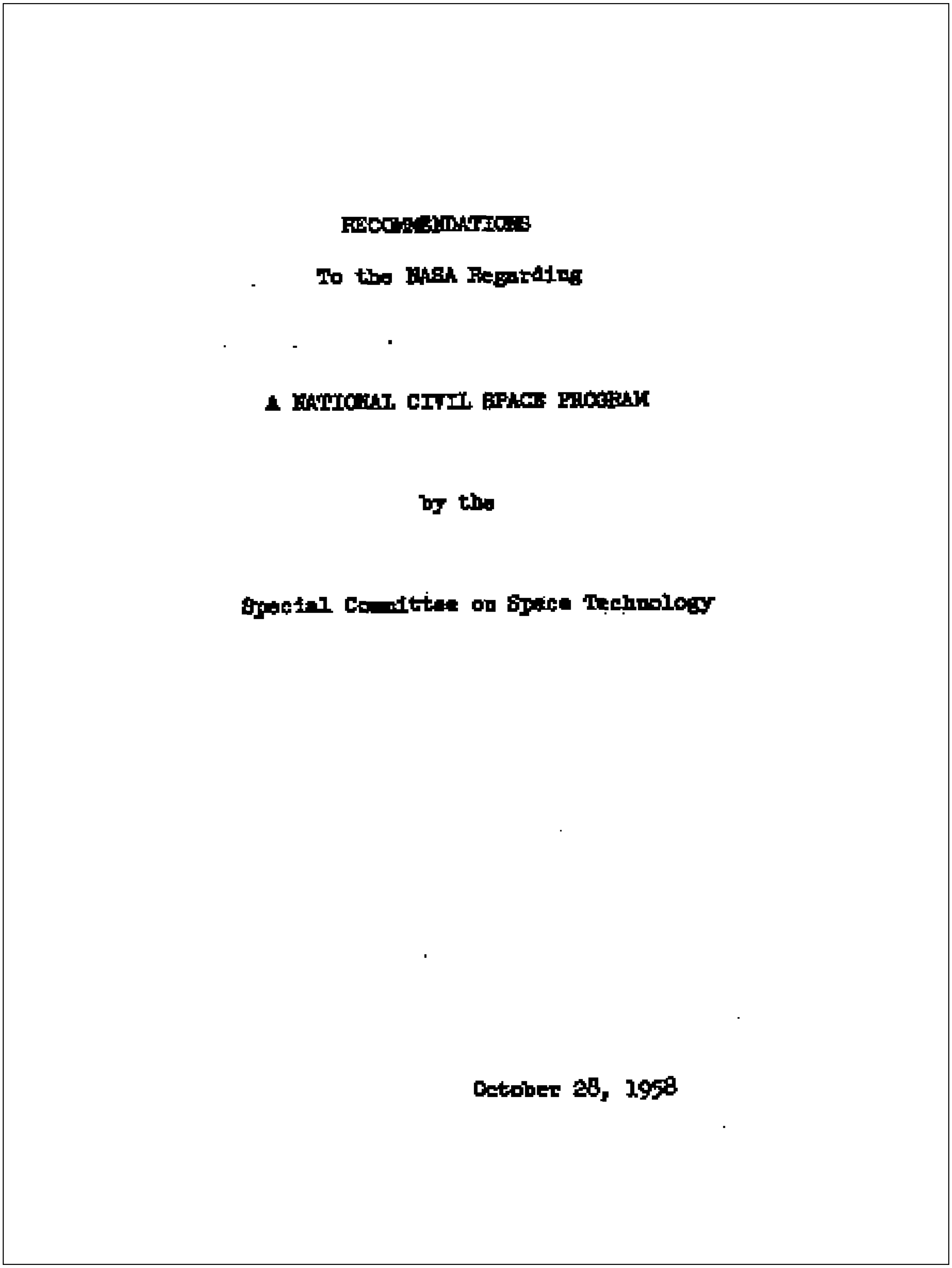
By the end of 1957, the NACA was heavily involved in space-related research, which constituted 40 to 50 percent of its total effort. Sensing that the NACA might be the obvious choice for taking the lead in the American space effort after Sputnik, on January 12, 1958, General James Doolittle, the NACA's chair, created a Special Committee on Space Technology. While NACA Director Hugh Dryden addressed the institutional issues involved in transforming the NACA into NASA, the Special Committee on Space Technology was charged with addressing specific areas of space technology deserving early attention. NASA was formally established on October 1, 1958, and the committee issued its final report at the end of that month. The following document reprints the recommendations to NASA on a national civil space program offered by the committee on October 28, 1958.



RECOMMENDATIONS

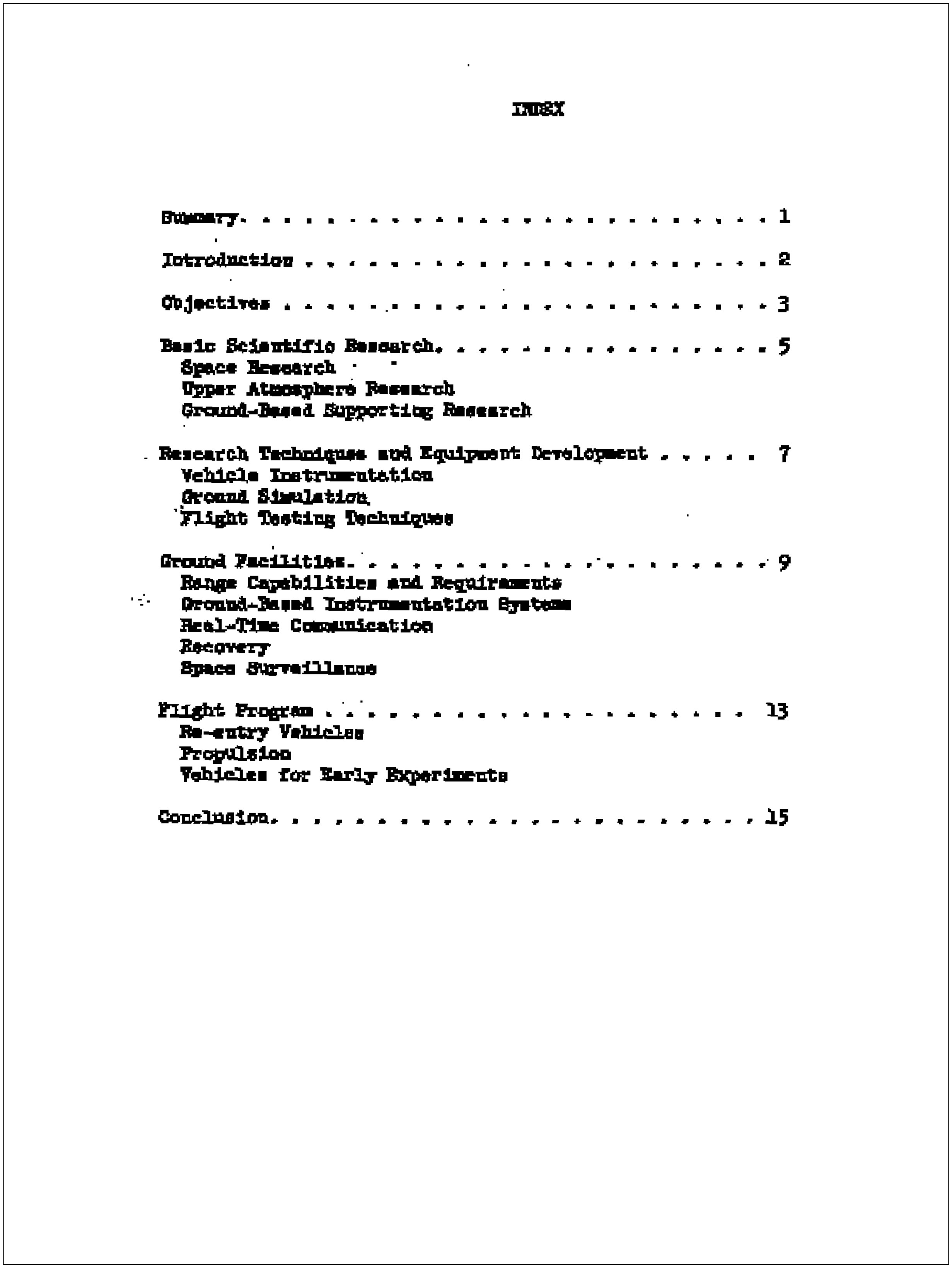
To the NASA Regarding

A NATIONAL CIVIL SPACE PROGRAM

by the

Special Committee on Space Technology

October 28, 1958



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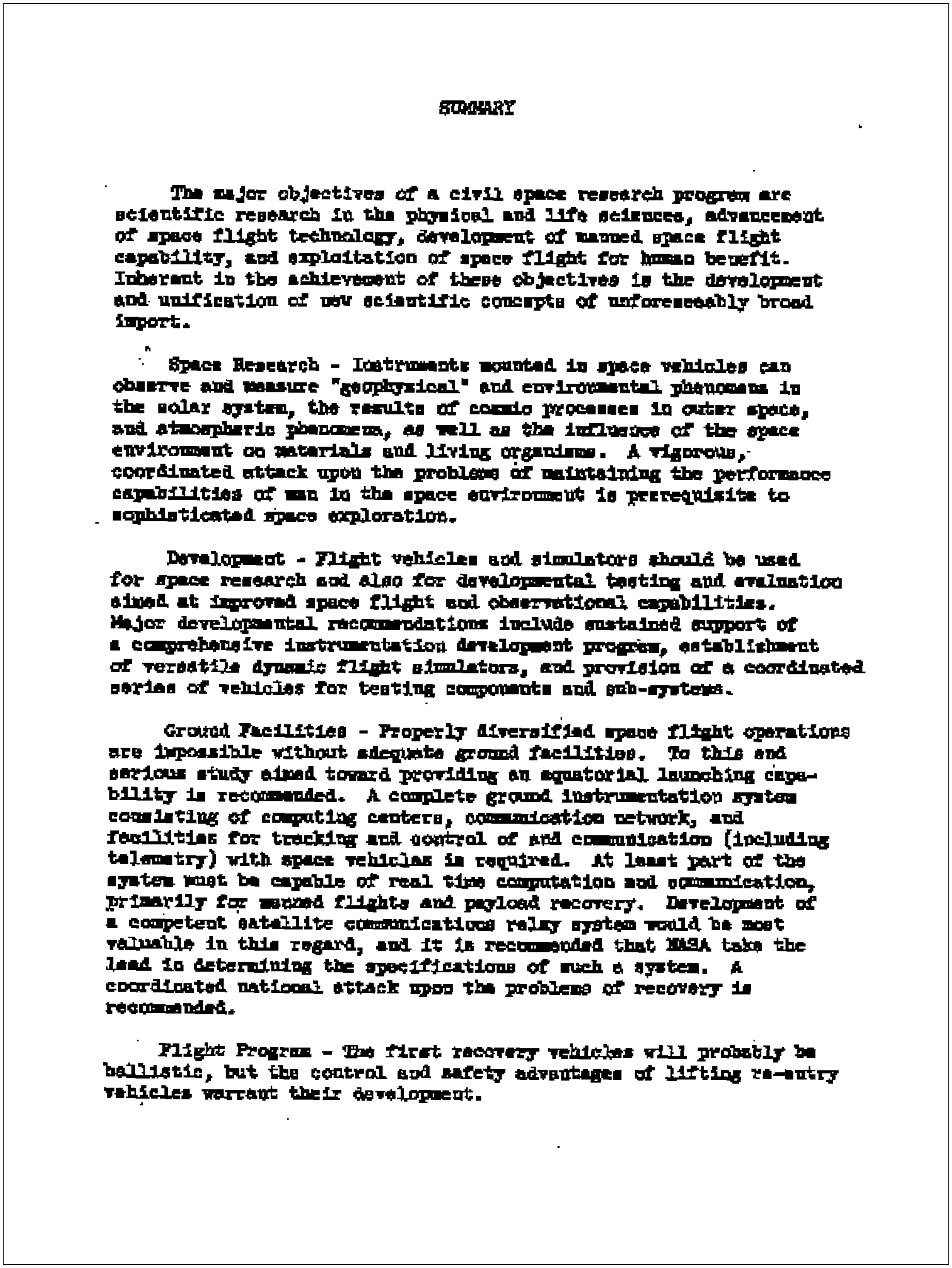


SUMMARY

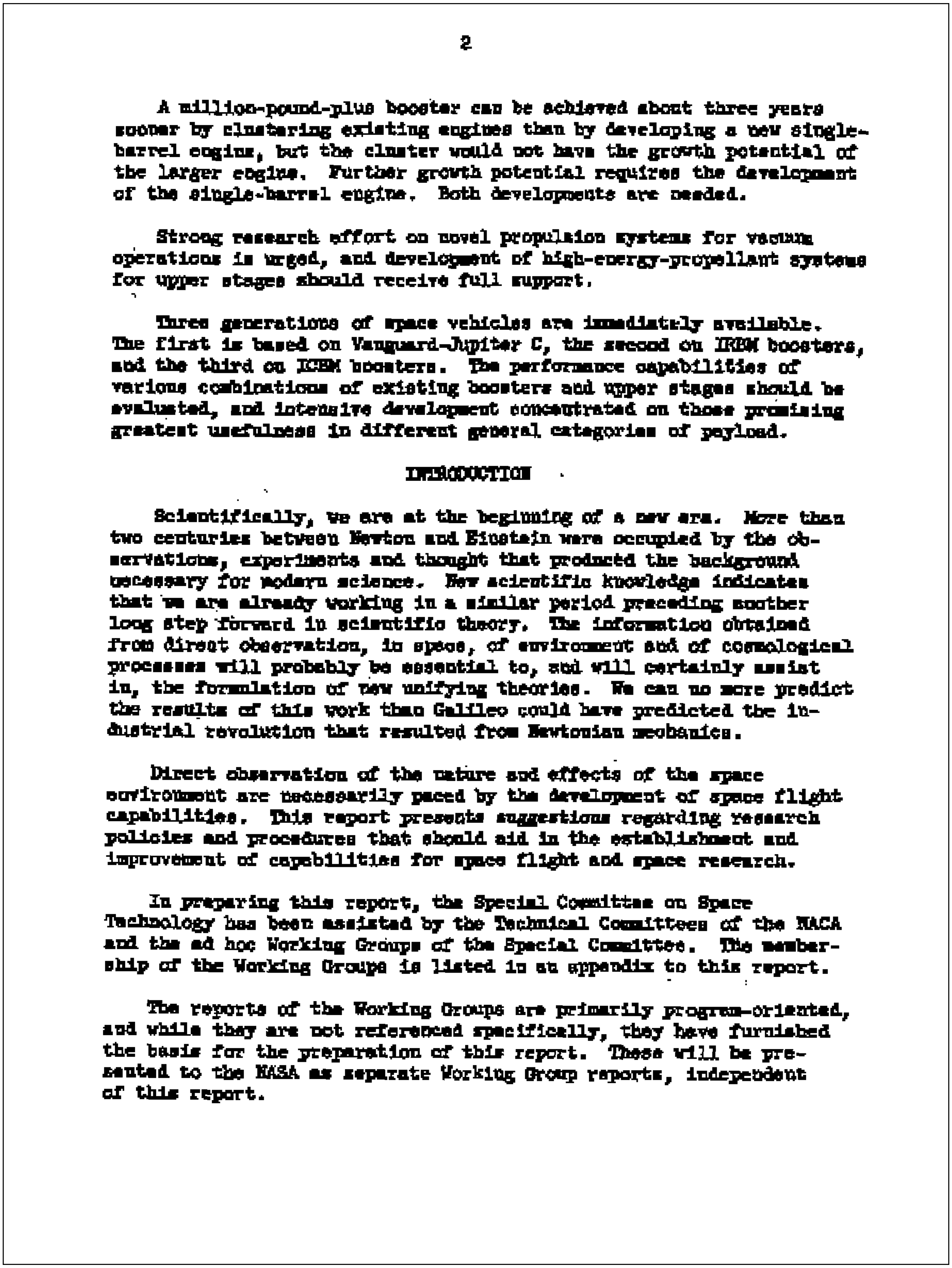
The major objectives of a civil space research program are scientific research in the physical and life sciences, advancement of space flight technology, development of manned space flight capability, and exploitation of space flight for human benefit. Inherent in the achievement of these objectives is the development and unification of new scientific concepts of unforeseeably broad import.

Space Research - Instruments mounted in space vehicles can observe and measure "geophysical" and environmental phenomena in the solar system, the results of cosmic processes in outer space, and atmospheric phenomena, as well as the influence of the space environment on materials and living organisms. A vigorous, coordinated attack upon the problems of maintaining the performance capabilities of man in the space environment is prerequisite to sophisticated space exploration.

Development - Flight vehicles and simulators should be used for space research and also for developmental testing and evaluation aimed at improved space flight and observational capabilities. Major developmental recommendations include sustained support of a comprehensive instrumentation development program, establishment of versatile dynamic flight simulators, and provision of a coordinated series of vehicles for testing components and sub-systems.

Ground Facilities - Properly diversified space flight operations are impossible without adequate ground facilities. To this end serious study aimed toward providing an equatorial launching capability is recommended. A complete ground instrumentation system consisting of computing centers, communication network, and facilities for tracking and control of and communication (including telemetry) with space vehicles is required. At least part of the system must be capable of real time computation and communication, primarily for manned flights and payload recovery. Development of a competent satellite communications relay system would be most valuable in this regard, and it is recommended that NASA take the lead in determining the specifications of such a system. A coordinated national attack upon the problems of recovery is recommended.

Flight Program - The first recovery vehicles will probably be ballistic, but the control and safety advantages of lifting re-entry vehicles warrant their development.



A million-pound-plus booster can be achieved about three years sooner by clustering existing engines than by developing a new single-barrel engine, but the cluster would not have the growth potential of the larger engine. Further growth potential requires the development of the single-barrel engine. Both developments are needed.

Strong research effort on novel propulsion systems for vacuum operations is urged, and development of high-energy-propellant systems for upper stages should receive full support.

Three generations of space vehicles are immediately available. The first is based on Vanguard-Jupiter C, the second on IRBM boosters, and the third on ICBM boosters. The performance capabilities of various combinations of existing boosters and upper stages should be evaluated, and intensive development concentrated on those promising greatest usefulness in different general categories of payload.

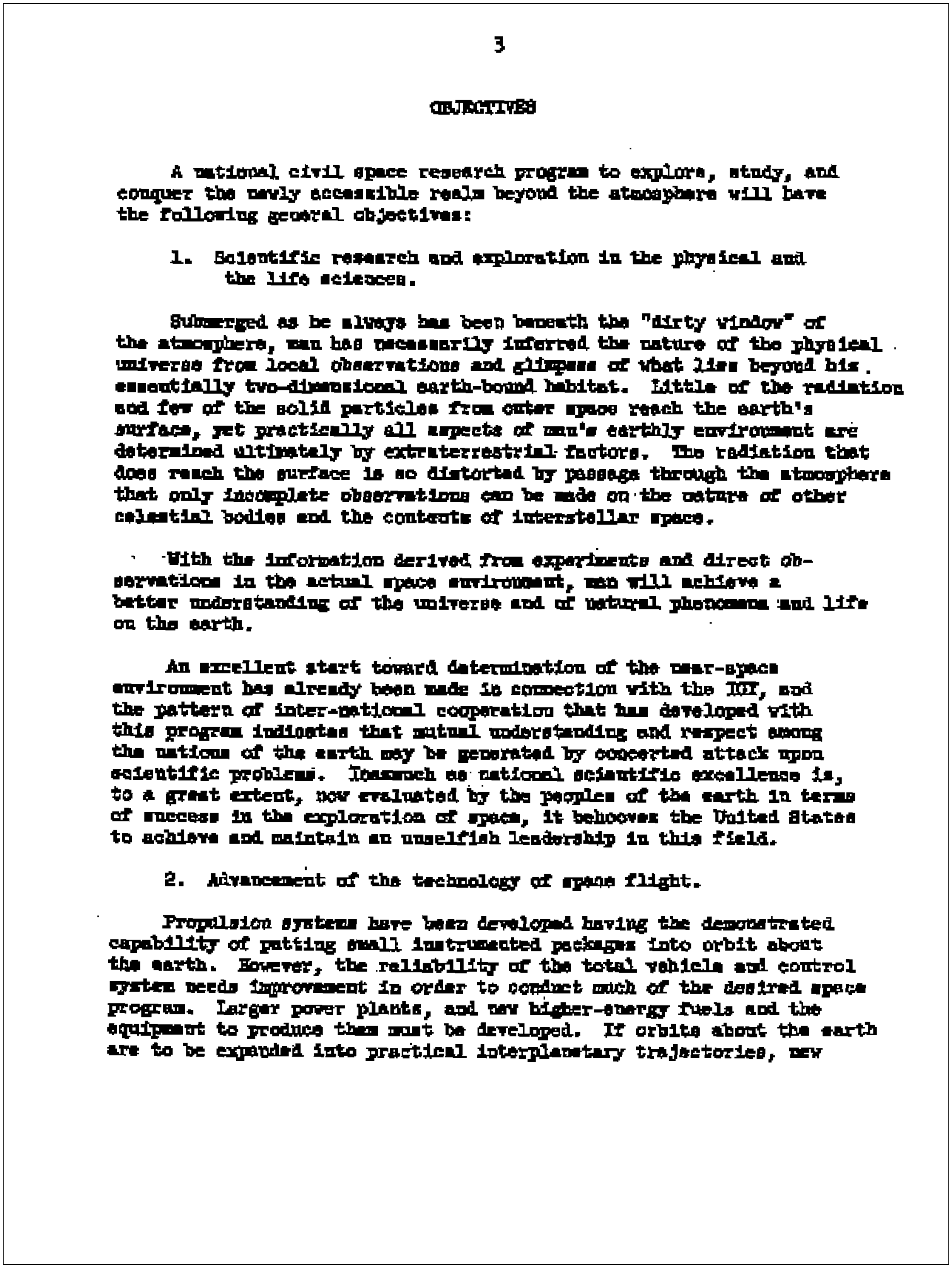
INTRODUCTION

Scientifically, we are at the beginning of a new era. More than two centuries between Newton and Einstein were occupied by the observations, experiments and thought that produced the background necessary for modern science. New scientific knowledge indicates that we are already working in a similar period preceding another long step forward in scientific theory. The information obtained from direct observation, in space, of environment and of cosmological processes will probably be essential to, and will certainly assist in, the formulation of new unifying theories. We can no more predict the results of this work than Galileo could have predicted the industrial revolution that resulted from Newtonian mechanics.

Direct observation of the nature and effects of the space environment are necessarily paced by the development of space flight capabilities. This report presents suggestions regarding research policies and procedures that should aid in the establishment and improvement of capabilities for space flight and space research.

In preparing this report, the Special Committee on Space Technology has been assisted by the Technical Committees of the NACA and the ad hoc Working Groups of the Special Committee. The membership of the Working Groups is listed in an appendix to this report.

The reports of the Working Groups are primarily program-oriented, and while they are not referenced specifically, they have furnished the basis for the preparation of this report. These will be presented to the NASA as separate Working Group reports, independent of this report.



OBJECTIVES

A national civil space research program to explore, study, and conquer the newly accessible realm beyond the atmosphere will have the following general objectives:

1. Scientific research and exploration in the physical and the life sciences.

Submerged as he always has been beneath the "dirty window" of the atmosphere, man has necessarily inferred the nature of the physical universe from local observations and glimpses of what lies beyond his essentially two-dimensional earth-bound habitat. Little of the radiation and few of the solid particles from outer space reach the earth's surface, yet practically all aspects of man's earthly environment are determined ultimately by extraterrestrial factors. The radiation that does reach the surface is so distorted by passage through the atmosphere that only incomplete observations can be made on the nature of other celestial bodies and the contents of interstellar space.

With the information derived from experiments and direct observations in the actual space environment, man will achieve a better understanding of the universe and of natural phenomena and life on the earth.

An excellent start toward determination of the near-space environment has already been made in connection with the IGY, and the pattern of inter-national cooperation that has developed with this program indicates that mutual understanding and respect among the nations of the earth may be generated by concerted attack upon scientific problems. Inasmuch as national scientific excellence is, to a great extent, now evaluated by the peoples of the earth in terms of success in the exploration of space, it behooves the United States to achieve and maintain an unselfish leadership in this field.

2. Advancement of the technology of space flight.

Propulsion systems have been developed having the demonstrated capability of putting small instrumented packages into orbit about the earth. However, the reliability of the total vehicle and control system needs improvement in order to conduct much of the desired space program. Larger power plants, and new higher-energy fuels and the equipment to produce them must be developed. If orbits about the earth are to be expanded into practical interplanetary trajectories, new propulsion systems having very low fuel consumption and modest thrust will be required in order that the trajectory can be controlled to perform the mission.

A good start has been made on the development of instrumentation for observing the environment in space. Instrumentation for controlling and navigating the vehicle and for communicating with the earth will require extensive development. Because of the severe weight restrictions, all instrumentation must be severely miniaturized. Ground-based communication systems must be expanded to provide for the control of and communication with vehicles on lunar or planetary missions, and for properly controlled re-entry and recovery.

Novel structural problems are posed by space vehicles. Heavy loads of steady acceleration, shock and vibration occur during boost, while weightlessness during unpowered space flight makes possible the use of unconventional mechanical design principles. For vehicles which must re-enter the earth's atmosphere, problems of structural integrity under high re-entry heating rates, large thermal gradients, and thermal shock are very important. All of these requirements must be met with an absolute minimum of structural weight.

Extensive human engineering developments are required in order for manned space flight to be successful. Because of the rigorous but largely unknown space environment, these developments will depend critically upon the information obtained in the early probing flights.

A successful National Space Program, therefore, requires continuing improvement and development in the pertinent fields of technology.

3. Manned space flight.

Instruments for the collection and transmission of data on the space environment have been designed and put into orbit about the earth. However, man has the capability of correlating unlikely events and unexpected observations, a capacity for overall evaluation of situations, and the background knowledge and experience to apply judgment that cannot be provided by instruments; and in many other ways the intellectual functions of man are a necessary complement to the observing and recording functions of complicated instrument systems. Furthermore, man is capable of voice communication for sending detailed descriptions and receiving information whereby the concerted judgement of others may be brought to bear on unforeseen problems that may arise during flight.

Although it is believed that a manned satellite is not necessary for the collection of environmental data in the vicinity of the earth, exploration of the solar system in a sophisticated way will require a human crew.

4. Exploitation of space for human benefit.

The practical exploitation of satellites and space vehicles for civil purposes and for human benefit may be as important as--or even more important than--the immediate military uses of space flight. Perhaps the most important example is the use of satellite vehicles for active or passive communications relay. This could extend what are effectively line-of-sight communication links for thousands of miles between points on the ground, with very great bandwidths and none of the capriciousness now characterizing long-range HF communications.

Many indirect benefits will also be derived from the technological developments that will make space flight practical. The necessarily high technological standards required for space flight will certainly accelerate improvement in transportation, communication and other contributions to human welfare.

The unpredictable long-term benefits of space-accelerated scientific and technological advancement will almost certainly far exceed the foreseeable benefits.

Aside from the intentional omission of military and political objectives, the foregoing objectives appear to be in consonance with those mentioned in "Introduction to Outer Space," by the President's Science Advisory Committee (Killian Committee), and with the objectives stated in the National Aeronautics and Space Act of 1958, which is the enabling lesiglation for the National Aeronautics and Space Administration.

BASIC SCIENTIFIC RESEARCH

Space Research

Geophysical observations from satellites and non-orbiting space probes enable the gravitational and magnetic fields in the vicinity of the earth to be mapped to altitudes limited only by the capabilities of the flight vehicle. The interactions among these fields and the particles and radiations approaching the earth from the sun and outer space can be studied, and related to the composition and behavior of the gaseous envelope of the earth from troposphere to exosphere. Satellite observations of large-scale cloud movements and other atmospheric phenomena can do much to put meteorology on a more sound scientific basis. As propulsion and guidance systems are improved, "geodetic" and "geophysical" studies can be extended to the moon and other planets.

Telescopes and spectroscopes mounted on earth satellites can utilize the complete radiation spectrum from vacuum ultraviolet to radio frequencies to observe the sun, the planets, stars, and interstellar space. Direct measurements of the space environment should include the nature, direction and intensity of electromagnetic and corpuscular radiation, and the nature and distribution of meteorites. The mass density in space can be measured, and large-scale magneto-hydrodynamic phenomena in and beyond the ionosphere can be studied. These observations and direct measurements will offer tremendous improvements in understanding of cosmic processes.

In addition to scientific observations and environmental measurements, satellite experiments will enable evaluation of the effect of the space environment on all types of material and biological specimens and hardware components. Re-entry phenomena can be studied, and here, for the first time, it is possible to investigate the effects of extended periods of weightlessness on instrumentation and living subjects.

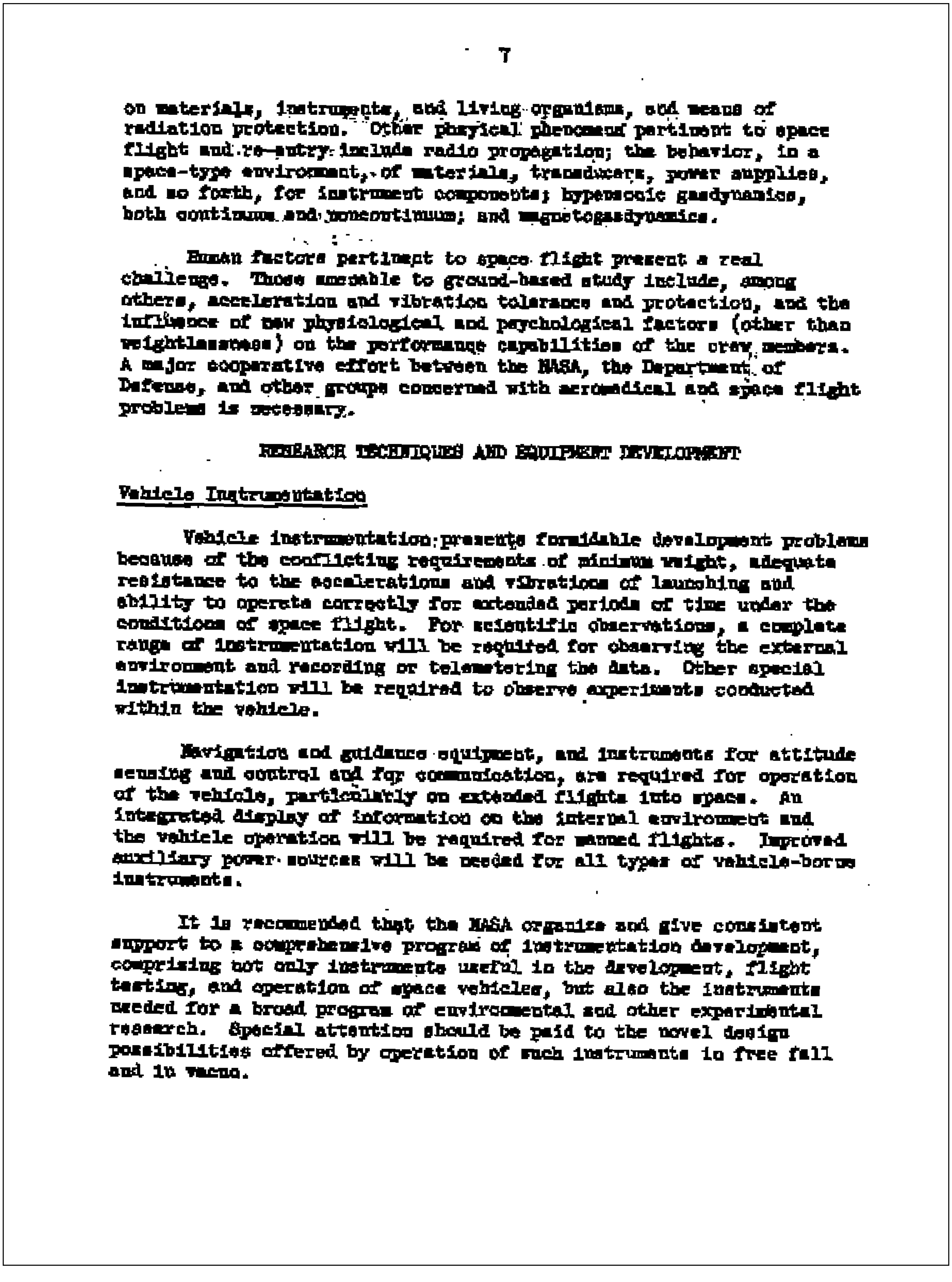
Experiments with man and other living organisms, both plant and animal, during extended periods in the space environment may offer new insight into human physiology and psychology and into life processes generally.

Upper Atmosphere Experiments

Upper atmosphere experiments, utilizing both rocket-propelled and balloon-supported vehicles, can, at reasonable cost, give direct information on both the vertical and time-wise variations of various atmospheric parameters and cosmic radiations. Heat-transfer, ablation, vehicle-control dynamics, and pilot-vehicle interactions can be studied under approximately re-entry conditions. Limited-time biological studies and human physiological and psychological studies under almost space conditions, and with limited periods of weightlessness, can also be investigated.

Ground-Based Supporting Research

In addition to direct study of the space environment, much ground-based research must be conducted as a basis for the space flight program. This will include such factors as radiation effects



on materials, instruments, and living organisms, and means of radiation protection. Other physical phenomena pertinent to space flight and re-entry include radio propagation; the behavior, in a space-type environment, of materials, transducers, power supplies, and so forth, for instrument components; hypersonic gasdynamics, both continuum and noncontinuum; and magnetogasdynamics.

Human factors pertinent to space flight present a real challenge. Those amenable to ground-based study include, among others, acceleration and vibration tolerance and protection, and the influence of new physiological and psychological factors (other than weightlessness) on the performance capabilities of the crew members. A major cooperative effort between the NASA, the Department of Defense, and other groups concerned with aeromedical and space flight problems is necessary.

RESEARCH TECHNIQUES AND EQUIPMENT DEVELOPMENT

Vehicle Instrumentation

Vehicle instrumentation presents formidable development problems because of the conflicting requirements of minimum weight, adequate resistance to the accelerations and vibrations of launching and ability to operate correctly for extended periods of time under the conditions of space flight. For scientific observations, a complete range of instrumentation will be required for observing the external environment and recording or telemetering the data. Other special instrumentation will be required to observe experiments conducted within the vehicle.

Navigation and guidance equipment, and instruments for attitude sensing and control and for communication, are required for operation of the vehicle, particularly on extended flights into space. An integrated display of information on the internal environment and the vehicle operation will be required for manned flights. Improved auxiliary power sources will be needed for all types of vehicle-borne instruments.

It is recommended that the NASA organize and give consistent support to a comprehensive program of instrumentation development, comprising not only instruments useful in the development, flight testing, and operation of space vehicles, but also the instruments needed for a broad program of environmental and other experimental research. Special attention should be paid to the novel design possibilities offered by operation of such instruments in free fall and in vacuo.

Ground Simulation of Environment and Operational Problems

The development and testing of a space vehicle, its components and, for a manned vehicle, its crew require ground simulation of the encironment and operating problems that will be encountered. The completeness of the simulation may well determine the success or failure of the mission. this will be a continuously changing problem as new information is obtained on the environment and as the operational ranges and durations increase.

Wind tunnels and jets of various types, ballistic ranges and structural test facilities, can simulate, to a reasonable extent, aerodynamic effects encountered during launching and re-entry. Vacuum chambers with assorted loading devices and radiation sources will be useful for both instrument and structural tests.

The capacity of a human crew to participate in the operation of a space vehicle is still an unknown quantity. As fast as such capabilities are demonstrated they should be utilized to the extent profitable in the operation of the vehicle. Therefore, flight simulators should be designed and built in which the flight dynamics and internal environment of space vehicles can be simulated as closely as possible. Such facilities would be used for pilot evaluation and training and for evaluation of the dynamic characteristics of the vehicle-pilot combination.

Flight Testing Techniques

To aid in the advanced development of space vehicles and sub-systems, and to complement the ground-based simulators, it is recommended that the NASA use reliable high-performance rocket-propelled test vehicles which would be standardized for as many tests as possible. In order to minimize the development cost of such vehicles, they should presumably be based on military developments in the missile field.

Two other techniques are recommended for larger-scale tests and for systems development and testing. One of these is a large, high-altitude, balloon-supported laboratory in which most conditions of space environment could be simulated. This balloon-supported laboratory would not only allow a substantial amount of research on the equipment needed by the space crew and on the effects of space environment on the capsule and its inhabitants, but could also be valuable for basic environmental studies.

The other is a nonorbiting rocket-propelled research vehicle capable of carrying at least two men, or an actual man-carrying satellite capsule. This vehicle should be capable of a number of minutes of free coast well above significant atmospheric influences. Such a vehicle could be used for development and final flight-testing of actual space capsules, for study of various recovery techniques, and for development of space flight controls and operational instrumentation. In addition, flight crews could be trained and evaluated under substantially longer periods of weightlessness than are possible within the atmosphere.

With the establishment of artificial earth satellites, space flight has become a reality, albeit on only a very limited scale. For more extended space missions, the long-time effects of the space environment on the vehicle and its contents must be known and designed for. This can best be studied in earth satellite vehicles. Strong technological support should be provided for all phases of vehicular development. Specifically, a substantial fraction of space flight missions should be allocated to such technological projects as components tests, materials tests, engine-restart tests, solar power supply systems, et cetera.

GROUND FACILITIES
for Space Flight Operations

Range Capabilities and Requirements

In view of the plans to expand the NASA Wallops Island facility for technique development and relatively small probe and satellite launchings, and with the Atlantic and the Pacific Missile Ranges capable of substantial further development, there is no present need for another major nonequatorial launching complex. It may be desirable, however, for the NASA to establish permanent field stations at both the Atlantic and Pacific Missile Ranges.

On the other hand, the unique properties of an equatorial orbit lead to a distinct need for an equatorial launching site. These are:

1. Narrow track over the earth's surface.

2. Best departure point for interplanetary operations.

3. Capability for all other orbits.

4. Minimum requirement for ground stations and communication system.

These considerations bring the Committee to the conclusion that the NASA should establish a study, survey and planning group aimed toward early provision of an equatorial launching capability, including necessary logistic support, for the United States. Fixed-base and ship-based launchings should be considered by the group before reaching a final decision.

Ground-Based Instrumentation System

The ground-based instrumentation needs of the civilian space program encompass such things as:

1. Communication with and transmission of commands to vehicles both near the earth and in interplanetary space.

2. Active and passive tracking of space vehicles.

3. Reception of telemetry signals from space.

4. Calculation of real-time search ephemeris data.

5. Calculation of final orbits for scientific analysis.

The instrumentation necessary can thus be listed as:

1. A network of stations suitably located for tracking of and communication with vehicles in interplanetary space. These stations must be tied together with reasonably rapid communication links. The stations will consist of very large antennas, sensitive receiving equipment, and high-power transmitting equipment.

2. A network of radio receiving stations to obtain orbital information from active satellites. These stations may be, in part at least, the same as those in the preceding paragraph.

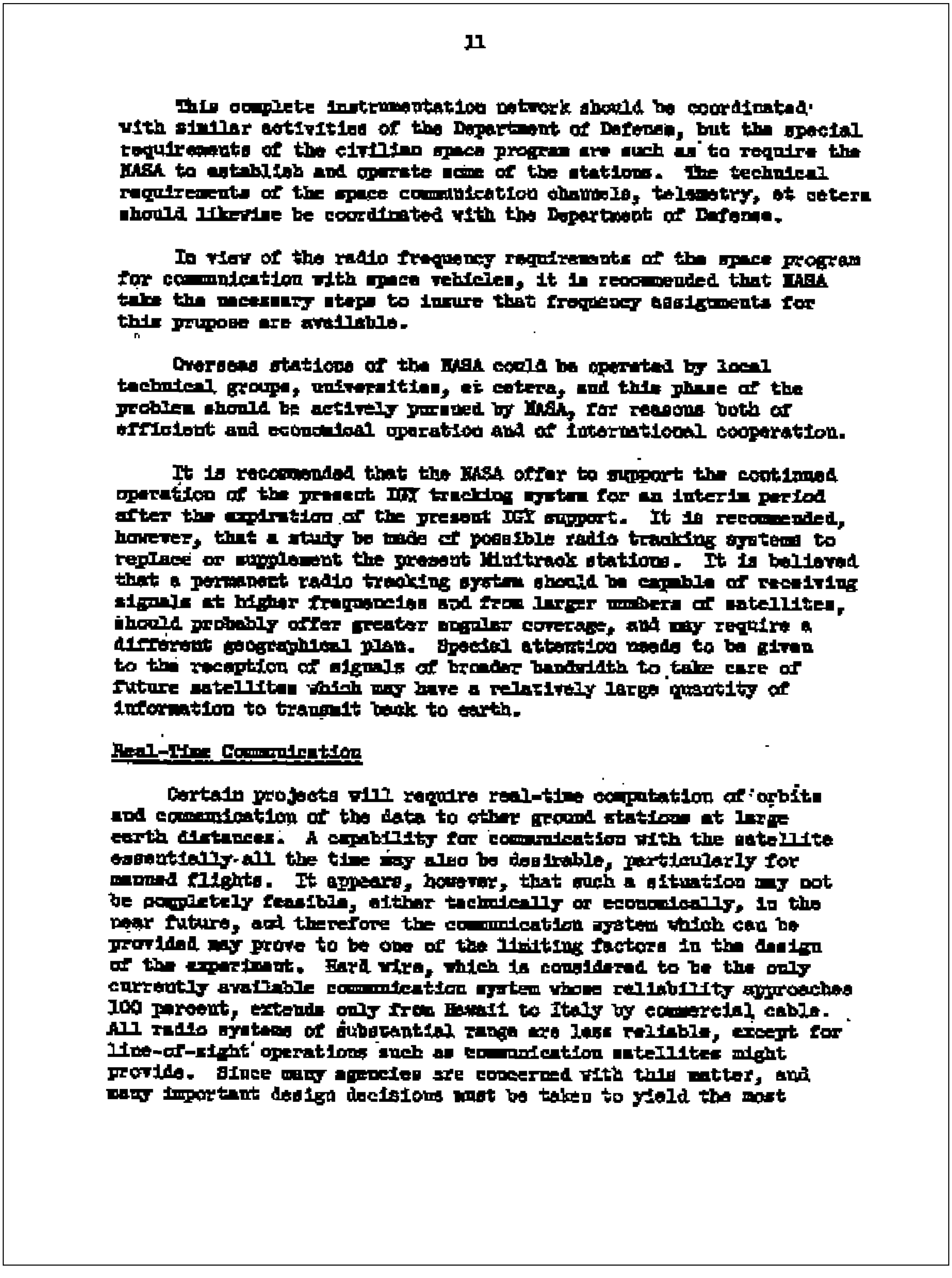
3. A network of optical stations to make very precise optical observations on some satellites, and a supplementary set of optical observing stations, probably similar to the present Moonwatch teams, for rough orbital data.

4. A set of telemetry receiving stations which will be in part, but not necessarily completely, at the other radio sites.

5. A special network of stations for re-entry experiments.

6. Computing facilities to calculate and publish search ephemeris data.

7. Computing facilities to generate orbital data of sufficient accuracy to satisfy scientific needs.



This complete instrumentation network should be coordinated with similar activities of the Department of Defense, but the special requirements of the civilian space program are such as to require the NASA to establish and operate some of the stations. The technical requirements of the space communication channels, telemetry, et cetera should likewise be coordinated with the Department of Defense.

In view of the radio frequency requirements of the space program for communication with space vehicles, it is recommended that NASA take the necessary steps to insure that frequency assignments for this prupose are available.

Overseas stations of the NASA could be operated by local technical groups, universities, et cetera, and this phase of the problem should be actively pursued by NASA, for reasons both of efficient and economical operation and of international cooperation.

It is recommended that the NASA offer to support the continued operation of the present IGY tracking system for an interim period after the expiration of the present IGY support. It is recommended, however, that a study be made of possible radio tracking systems to replace or supplement the present Minitrack stations. It is believed that a permanent radio tracking system should be capable of receiving signals at higher frequencies and from larger numbers of satellites, should probably offer greater angular coverage, and may require a different geographical plan. Special attention needs to be given to the reception of signals of broader bandwidth to take care of future satellites which may have a relatively large quantity of information to transmit back to earth.

Real-Time Communication

Certain projects will require real-time computation of orbits and communication of the data to other ground stations at large earth distances. A capability for communication with the satellite essentially all the time may also be desirable, particularly for manned flights. It appears, however, that such a situation may not be completely feasible, either technically or economically, in the near future, and therefore the communication system which can be provided may prove to be one of the limiting factors in the design of the experiment. Hard wire, which is considered to be the only currently available communication system whose reliability approaches 100 percent, extends only from Hawaii to Italy by commercial cable. All radio systems of substantial range are less reliable, except for line-of-sight operations such as communication satellites might provide. Since many agencies are concerned with this matter, and many important design decisions must be taken to yield the most generally useful satellite communications relay system, NASA should take the initiative in coordinating the various requirements and settling on a preferred system at the earliest possible date. Furthermore, projects requiring real-time communication should formulate a rather complete communications plan early in the project-planning stage.

Recovery

The requirements for recovery of instrumented and manned satellites from orbital flight pose problems involving equipment, communication, and operation which are of very great magnitude. The escape maneuver during both the launch and the recovery phases will require recovery capability over large areas of the Atlantic Ocean, the Pacific Ocean, and possibly the United States Zone of the Interior.

It appears that a coordinated national effort is required to cope with this problem.

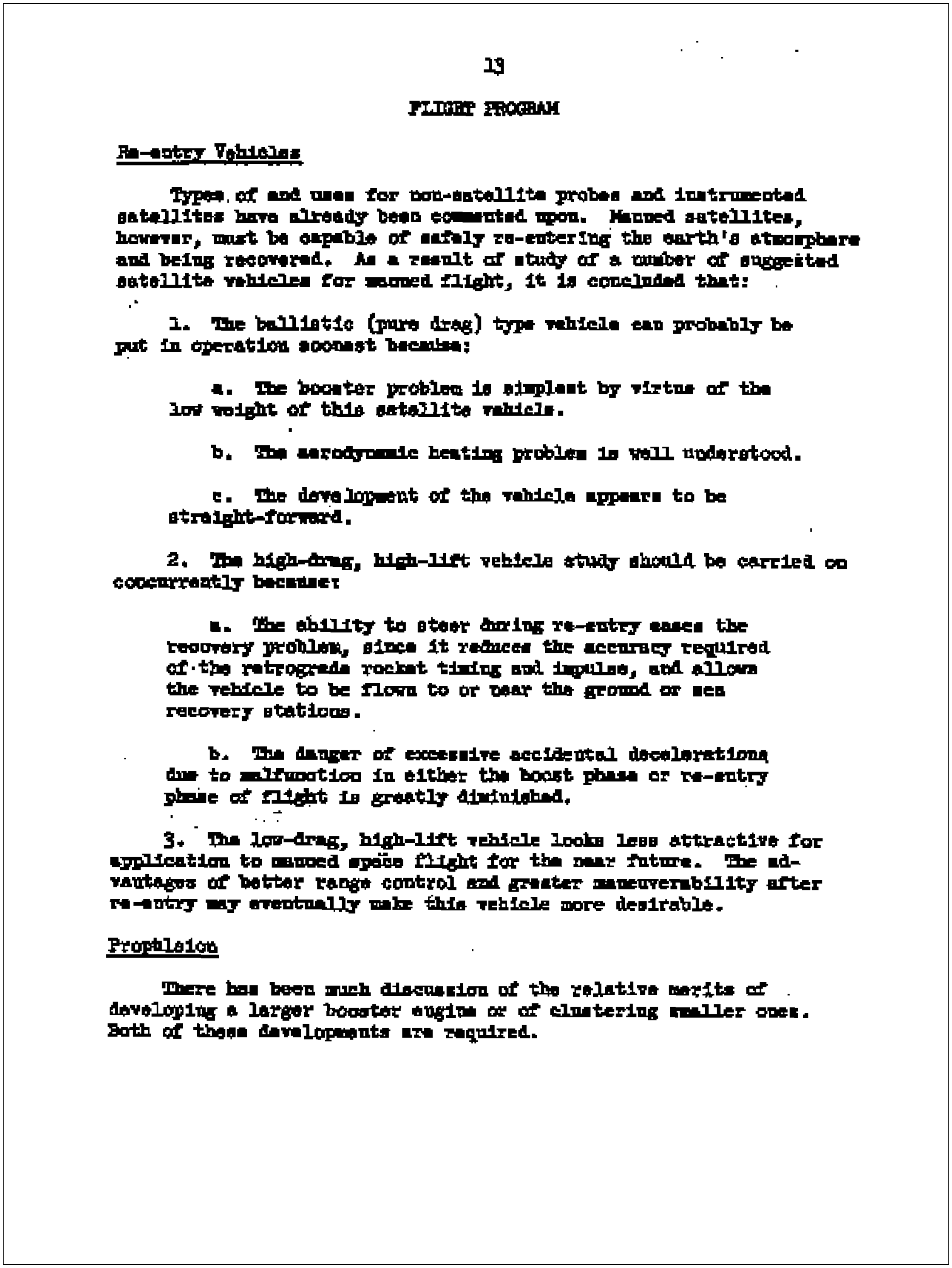
It is recommended, therefore, that NASA establish a working group on recovery systems which will summarize the experience obtained to date, will define the problems to be solved, and propose operational techniques and equipment which should be developed.

One possible solution would be for the Atlantic, Pacific, and White Sands Missile Ranges to establish coordinated operational groups for these three areas, making maximum use of existing organization and facilities, for all national space programs requiring recovery techniques.

Space Surveillance Problems

It is not considered necessary for NASA to set up the ground equipment and to maintain current ephemerides of all passive satellites, although, of course, ephemerides will be required for all satellites during the course of their experiments and for all satellites intended for recovery.

It is considered important that some kind of control be applied to limit the life of any satellite radio transmitter to a reasonable duration of experiment, in order to prevent cluttering up useful parts of the radio spectrum. However, no non-military need is anticipated, at this time, for a "vacuum cleaner" to remove from orbit the satellites that have outlived their usefulness.



FLIGHT PROGRAM

Re-entry Vehicles

Types of and uses for non-satellite probes and instrumented satellites have already been commented upon. Manned satellites, however, must be capable of safely re-entering the earth's atmosphere and being recovered. As a result of study of a number of suggested satellite vehicles for manned flight, it is concluded that:

1. The ballistic (pure drag) type vehicle can probably be put in operation soonest because:

   a. The booster problem is simplest by virtue of the low weight of this satellite vehicle.

   b. The aerodynamic heating problem is well understood.

   c. The development of the vehicle appears to be straight-forward.

2. The high-drag, high-lift vehicle study should be carried on concurrently because:

   a. The ability to steer during re-entry eases the recovery problem, since it reduces the accuracy required of the retrograde rocket timing and impulse, and allows the vehicle to be flown to or near the ground or sea recovery stations.

   b. The danger of excessive accidental decelerations due to malfunction in either the boost phase or re-entry phase of flight is greatly diminished.

3. The low-drag, high-lift vehicle looks less attractive for application to manned space flight for the near future. The advantages of better range control and greater maneuverability after re-entry may eventually make this vehicle more desirable.

Propulsion

There has been much discussion of the relative merits of developing a larger booster engine or of clustering smaller ones. Both of these developments are required.

Schedule studies clearly indicate that a booster of one million pounds thrust or more could be available about three years earlier if it were based on the clustering of existing rocket engines. This would lead to a fourth generation of space vehicles (with Vanguard-Jupiter C being the first; IRBM-boosted space vehicles being the second; ICBM-boosted vehicles the third generation.) Progress in the rocket engine field offers a high degree of confidence that a multiple-barrel booster of one to one and a half million pounds total thrust could be ready for flight test in two to three years. Fifth-generation boosters based on the one million pounds-plus thrust, single-barrel engine (whether using one such engine or several) would offer orbital payloads up to 100,000 pounds, and would be available three years later.

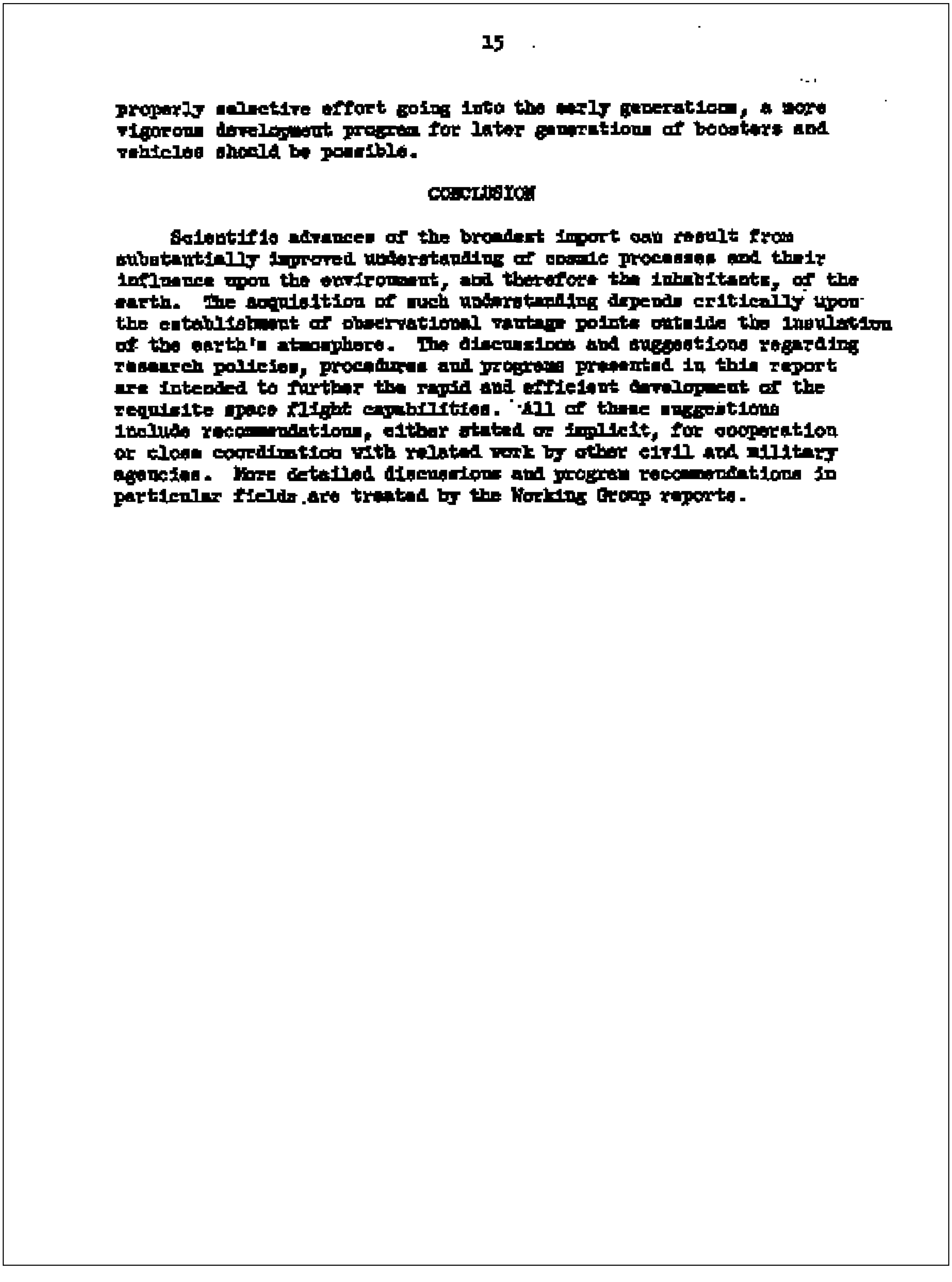
It is strongly recommended that a study be made to assess the advisability of developing recoverable first-stage boosters. Recovery techniques should be optimized from a systems point of view.

Strong research effort on novel propulsion systems for vacuum operations is urged, and development of high-energy-propellant systems for upper stages should receive full support.

Vehicles for Early Experiments

In the preceding section several generations of space vehicle boosters are identified in general terms. The first generation, already in being, is capable of putting into orbit payloads of approximately 30 pounds. Such a vehicle enables the observation of a relatively small number of space environmental factors, or the conduct of simple experiments in the space environment. The second generation, with payload capabilities up to roughly 300 pounds, enables more sophisticated or larger numbers of experiments and environmental observations. The third-generation vehicles should make possible payloads of 3,000 pounds or more. Heavy or bulky observing instruments with provision for long-time attitude control and data transmission can be carried, and minimal manned space flights should be possible.

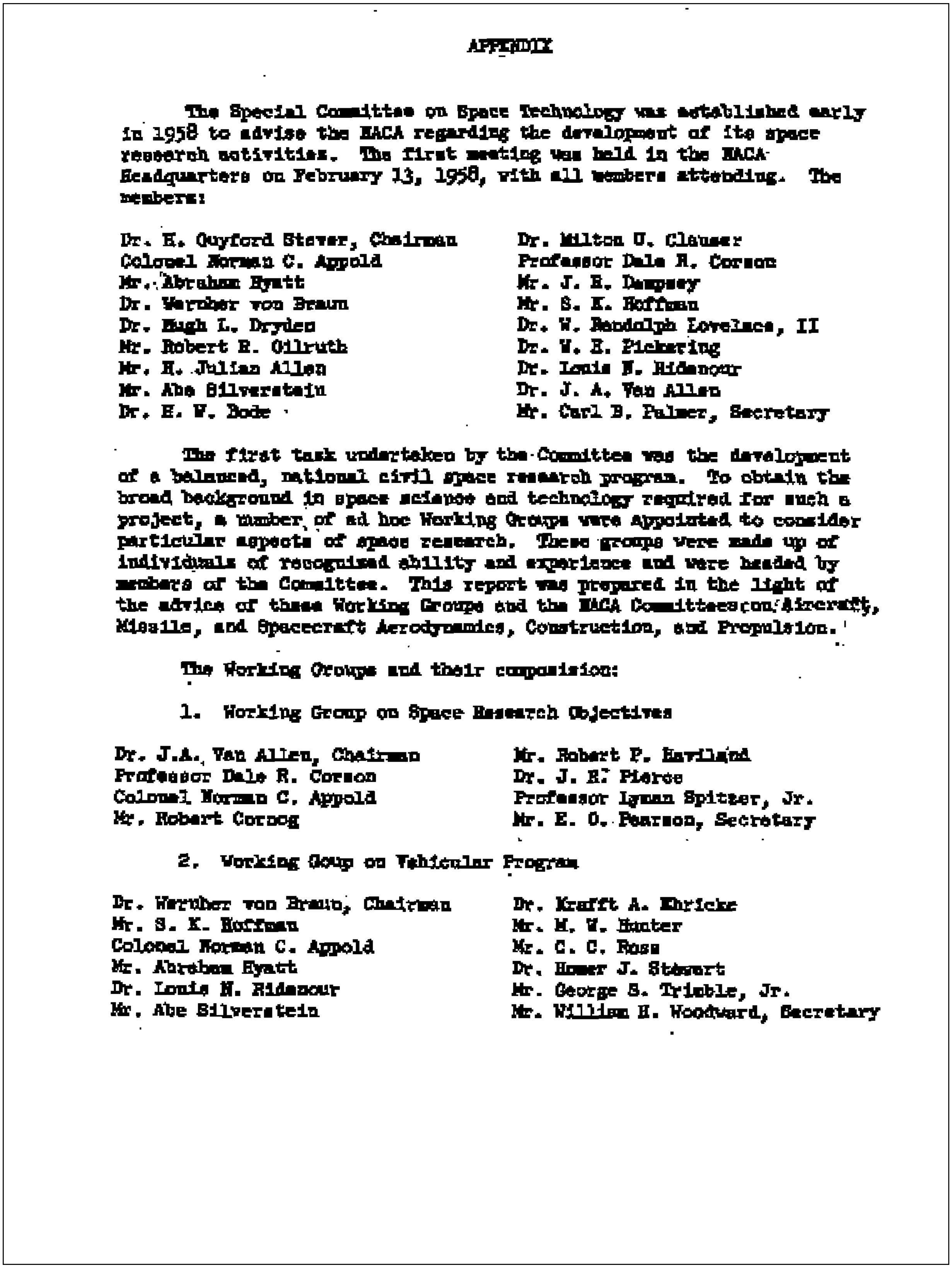
In each of these generations a number of boosters and upper stages are either available or under development. Proper combinations of these should make possible a wide spectrum of payloads and performances. Furthermore, it is likely that early generation vehicles will continue to be used even after later generation vehicles are available. Therefore the NASA should make a thorough study of the capabilities of existing stages to determine whether there are any serious gaps in the spectrum, and to select particular combinations for further development and use in its early experiments. With



properly selective effort going into the early generations, a more vigorous development program for later generations of boosters and vehicles should be possible.

CONCLUSION

Scientific advances of the broadest import can result from substantially improved understanding of cosmic processes and their influence upon the environment, and therefore the inhabitants, of the earth. The acquisition of such understanding depends critically upon the establishment of observational vantage points outside the insulation of the earth's atmosphere. The discussions and suggestions regarding research policies, procedures and programs presented in this report are intended to further the rapid and efficient development of the requisite space flight capabilities. All of these suggestions include recommendations, either stated or implicit, for cooperation or close coordination with related work by other civil and military agencies. More detailed discussions and program recommendations in particular fields are treated by the Working Group reports.



APPENDIX

The Special Committee on Space Technology was established early in 1958 to advise the NACA regarding the development of its space research activities. The first meeting was held in the NACA Headquarters on February 13, 1958, with all members attending. The members:

Dr. H. Guyford Stever, Chairman
Colonel Norman C. Appold
Mr. Abraham Hyatt
Dr. Wernher von Braun
Dr. Hugh L. Dryden
Mr. Robert R. Gilruth
Mr. H. Julian Allen
Mr. Abe Silverstein
Dr. H. W. Bode

Dr. Milton U. Clauser
Professor Dale R. Corson
Mr. J. R. Dempsey
Mr. S. K. Hoffman
Dr. W. Randolph Lovelace, II
Dr. W. H. Pickering
Dr. Louis N. Ridenour
Dr. J. A. Van Allen
Mr. Carl B. Palmer, Secretary

The first task undertaken by the Committee was the development of a balanced, national civil space research program. To obtain the broad background in space science and technology required for such a project, a number of ad hoc Working Groups were appointed to consider particular aspects of space research. These groups were made up of individuals of recognized ability and experience and were headed by members of the Committee. This report was prepared in the light of the advice of these Working Groups and the NACA Committees on Aircraft, Missile, and Spacecraft Aerodynamics, Construction, and Propulsion.

The Working Groups and their composition:

1. Working Group on Space Research Objectives

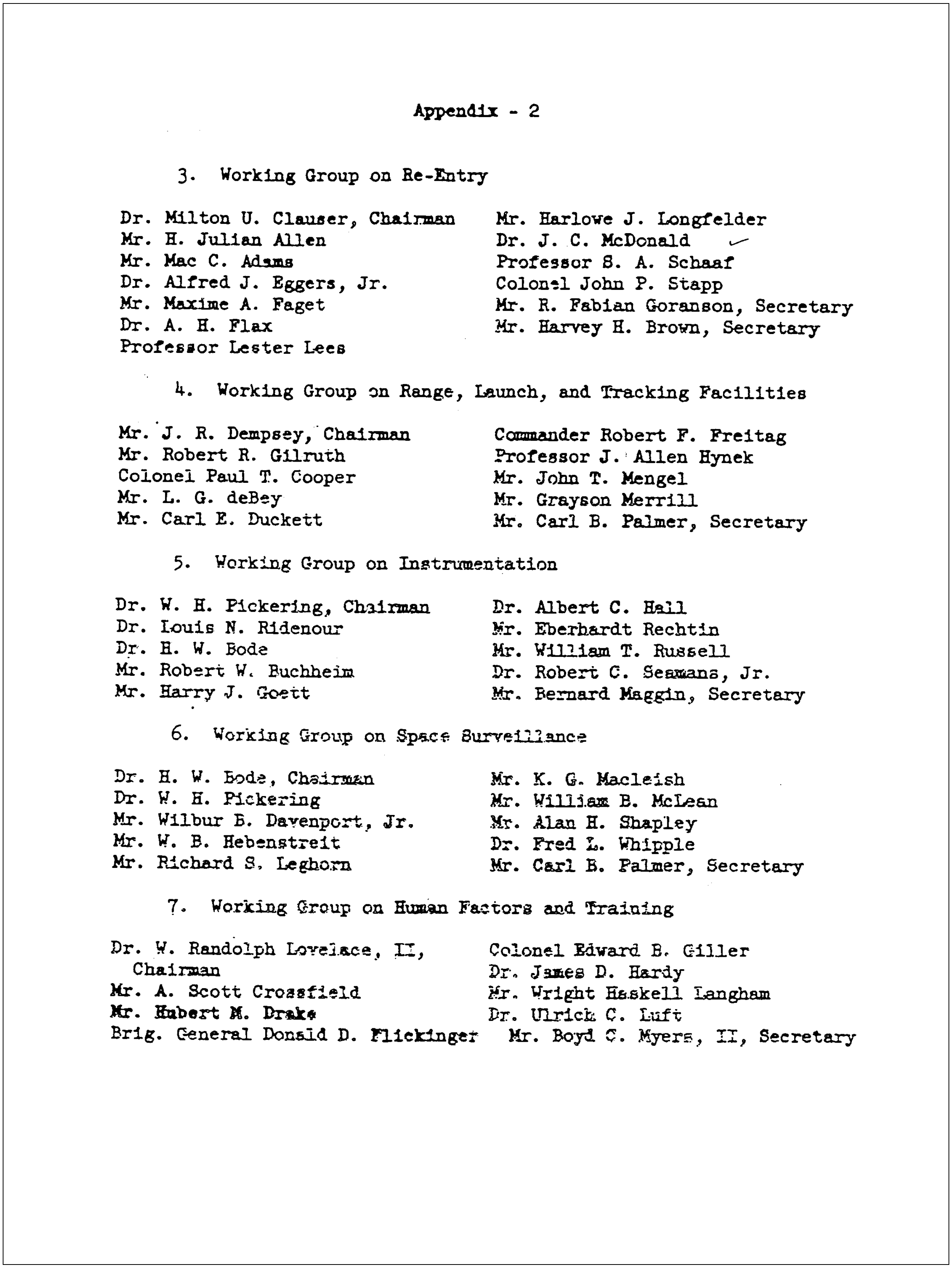
Dr. J.A. Van Allen, Chairman
Professor Dale R. Corson
Colonel Norman C. Appold
Mr. Robert Cornog

Mr. Robert P. Haviland
Dr. J. R. Pierce
Professor Lyman Spitzer, Jr.
Mr. E. O. Pearson, Secretary

2. Working Goup on Vehicular Program

Dr. Wernher von Braun, Chairman
Mr. S. K. Hoffman
Colonel Norman C. Appold
Mr. Abraham Hyatt
Dr. Louis N. Ridenour
Mr. Abe Silverstein

Dr. Krafft A. Ehricke
Mr. M. W. Hunter
Mr. C. C. Ross
Dr. Homer J. Stewart
Mr. George S. Trimble, Jr.
Mr. William H. Woodward, Secretary



Appendix - 2

3. Working Group on Re-Entry

Dr. Milton U. Clauser, Chairman
Mr. H. Julian Allen
Mr. Mac C. Adams
Dr. Alfred J. Eggers, Jr.
Mr. Maxime A. Faget
Dr. A. H. Flax
Professor Lester Lees
Mr. Harlowe J. Longfelder
Dr. J. C. McDonald
Professor S. A. Schaaf
Colonel John P. Stapp
Mr. R. Fabian Goranson, Secretary
Mr. Harvey H. Brown, Secretary

4. Working Group on Range, Launch, and Tracking Facilities

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