writing, I would tell him to work at his reading, to spend 2 or 3 years doing some nontechnical reading: read novels, plays, short stories, poetry, travel, history, current events; read argumentation and controversy, humorous or otherwise; read Standen's *Science Is a Sacred Cow*, or Barzun's *Science the Glorious Entertainment*. Let him read Winston Churchill until the rhythm of Churchillian prose works into his subconscious. Try reading out loud. Try listening to records such as the Oxford prose selections, or the four assassins in T. S. Eliot's *Murder in the Cathedral*, or his *Cocktail Party*. Or try listening to the scads of poetry readings that are available; Lewis Casson reading Tennyson's *Ulysses* and Sybil Thorndike reading the *Lady of Chalot* will haunt you. Read several of the literate books on writing, including technical writing and usage: Strunk and White, *The Elements of Style*; Menzel, Jones, and Boyd, *Writing a Technical Paper*; Vallins, *Good Writing, Better Writing*; Graves and Hodges, *The Reader Over Your Shoulder*; Gunning, *The Technique of Clear Writing*; Flesch, *The Art of Plain Talk*; Gowers, *Plain Words: Their ABC*.

His reading will do him fully as much good as any technical writing course. And if he does indeed conscientiously read more and analyze what he reads for a year or two, he will probably give it three or four and more. He'll be hooked on reading. If his writing doesn't improve, it won't be any worse. And he will have become that surprising, delightful, and all too rare person—the literate scientist.

NEWS AND COMMENT

Post-Apollo: NASA Seeks a Mars Flight Plan

Today, in the wake of the successful Apollo mission, President Nixon and the Congress face a critical question of space policy not unlike that which confronted President Kennedy and the Congress in 1961. For President Kennedy the question was whether the United States should land men on the moon by 1970. Kennedy said Yes. Now it is up to Nixon to say Yes, No, or Maybe to the question of whether to send men to Mars in the early 1980's.

The question now, as then, is whether the United States shall commit itself to a program of manned space exploration which is so ambitious, and so demanding of money and talent, as to overshadow all other space activities—and to constitute, far and away, the nation's single largest venture in science and technology.

While the policy question posed today is similar to that of 1961, the circumstances in which it must be decided are vastly different from those that prevailed when John Kennedy occupied the White House. In 1961, the Soviet Union, having just placed a man in orbit, was ahead of the United States in the technology of manned flight, and this was a politically embarrassing matter. Today it is the United States that is well in the lead. And, today, the space program faces far keener competition for resources than it did in the early years of Apollo. A frustrating and seemingly endless war has led to huge defense expenditures, and a multitude of domestic problems cry for solutions which invariably are costly.

On the other hand, the success of Apollo demonstrates that NASA thus far has not overreached the state of technology. And this, surely, gives greater credence to the agency's claims for the future. A manned expedition to Mars in the early 1980's would involve a round trip of hundreds of millions of miles, as compared to the relatively comfortable 476,000-mile trip taken by the Apollo 11 astronauts. Yet Homer E. Newell, NASA's associate administrator, says that such an expedition would be "no bolder, no more risky" than was Apollo, a program begun even before the United States had made its first manned orbital flight and while NASA was still a fledgling organization.

Thomas O. Paine, NASA Administrator

There is still another major new circumstance almost certain to influence the outcome of the current national deliberations on the future of the space program. For Apollo, NASA built up a big in-house and contractor establishment, an establishment which is now anxious to be given another large mission and the billions of dollars necessary to finance it. Several years hence all of the Apollo flights currently programmed will have been completed and all the orbital workshop activity planned under the Apollo Applications Program (AAP) will have been carried out. What, then, will become of such elaborate NASA facilities as the Manned Spacecraft Center at Houston and the Marshall Space Flight Center at Huntsville if another large program of manned space activities has not gotten underway?

The aerospace industry as a whole looks to NASA for about 15 percent of its business, and some companies, such as North American Aviation, manufacturer of the Apollo spacecraft, have depended very heavily on NASA contracts. The industry's self-interest in the perpetuation of Apollo-type programs is manifest. If there is a "military-industrial complex" behind defense projects such as the Safeguard antiballistic missile, one may safely assume

Homer E. Newell, Associate Administrator of NASA

that there is also a complex of sorts behind proposals for manned exploration of Mars.

Within the next few weeks President Nixon is expected to decide what direction the space program shall take in the 1970's. A Space Task Group (STG), assembled by the President and chaired by Vice President Agnew, has been at work since March on the preparation of recommendations for a policy to guide the space program during the next decade or so. Besides Vice President Agnew, members of the STG include Lee DuBridge, the president's science adviser; Thomas O. Paine, administrator of NASA; and Robert C. Seamans, secretary of the Air Force and formerly NASA's deputy administrator. This is not a group hostile to manned space flight on the grand scale. Paine and Seamans live in a world of celestial experiences, and Agnew and DuBridge have, for their part, both said that the nation will want to send men to Mars before the end of this century.

According to DuBridge, the STG report will be presented to the President soon after he returns from the West Coast on 7 September. The President will consider the various options set forth in the report and make his decision, which presumably will be announced by October. Then it will be up to Congress, next year and in subsequent years, to decide whether to authorize and fund the activities that the President's program calls for.

What are the options the President will consider? It seems certain that the STG is not going to forsake any of the three principal areas of space activity in which NASA has been engaged—scientific exploration with automated spacecraft; the development of "applications" satellites for communications, navigation, meteorology, and the survey of earth resources; and the further development of capabilities for manned space flight.

The space agency's plans for automated missions during the 1970's follow closely the recommendations of its Lunar and Planetary Missions Board, a body of outside scientists, and of the Space Science Board of the National Academy of Sciences. The Space Science Board, in reports made public during the last year, has called for a series of unmanned missions to the nearer planets—Mars, Venus, and Mercury—up through the mid-1970's and for missions to the outer planets—Jupiter, Saturn, Uranus, Neptune, and Pluto—during the period from 1974 through the early 1980's.

These proposals, by and large, are likely to be considered favorably in the STG report, especially since NASA's past automated lunar and planetary missions have produced excellent scientific returns and yet have required only a small share of the agency budget. On 22 August, in a speech at an aerospace dinner in California, DuBridge observed that "unmanned flyby and orbiting spacecraft to all of these (the near and outer) planets are now within range of current technology, and the late 1970's will see an unusual opportunity for spacecraft to make grand tours of all the outer planets." DuBridge also spoke enthusiastically of the potential of orbital astronomical observatories, of which one is now operating and transmitting data.

A number of members of Congress, and especially Representative Joseph E. Karth of Minnesota, chairman of the Subcommittee on Space Science and Applications, have urged that NASA push the development of applications satellites and thus hasten the day when the nation gets direct and substantial payoffs from the billions invested in space activities. DuBridge also has noted the benefits to be gained from pressing ahead with the development of such satellites. As is true in the case of automated spacecraft for scientific missions, the cost of developing these satellites is small by comparison with the cost of manned flight. A good guess is that most, if not all, the program options put before the President will call for a greater effort in this space applications area.

Clearly, the question with which the STG has had mainly to deal is that of the direction and pace of the manned space program, especially the pace. According to DuBridge, NASA officials are "pushing very hard" for a national commitment to a manned Mars expedition in the early 1980's. While this must be taken as an authoritative interpretation of an ultimate NASA goal, the agency's position, as set forth by its officials in various statements and interviews, is more complicated than that. Though it no doubt would be delighted to have the President and the Congress adopt forthwith a goal of going to Mars, NASA discusses the Mars venture in a somewhat conditional way and as something for which no commitment is needed before the mid-1970's.

What should now be done, NASA says, is to proceed with a new Integrated Program of developing the vehicles, space stations, and other equipment that will be necessary if the nation is to have, in 1974 or 1976, the choice of deciding whether to go to Mars in 1981 or 1983. Should the decision be not to go, the new flight capabilities which have been developed will by no means be wasted, NASA says, for the cost of space flight will have been greatly reduced and major new opportunities opened up for lunar exploration and a variety of scientifically and technologically productive missions in earth orbit.

The premise here is that man will and should go on many space missions, even if not on missions to the planets.

Members of the STG do believe in manned space flight, and, from all the indications, the options this group has prepared for the President consist partly of various time tables—and projected space budgets—by which NASA's Integrated Program, or something closely akin to it, can be achieved. According to Paine, the NASA administrator, if new manned flight capabilities are not to be developed fast enough to allow a manned Mars expedition in the early 1980's, the only alternative likely to be considered will be that of proceeding with the same development stretched out over a longer time.

Before considering some of the opinions expressed by scientists and members of Congress about how NASA should proceed, let us examine briefly what NASA's proposed Integrated Program consists of. This program would involve the early development of three important new items of space equipment: (i) a reusable, chemical-fuel space shuttle which, serving as the upper stage of the presently existing Saturn V rocket, would transport people, equipment, and supplies in support of earth orbital missions and then return to earth for a conventional landing; (ii) a space tug (having somewhat the appearance of Apollo's lunar excursion module) which would be the maneuvering unit for earth and lunar orbital missions and for lunar landings; and (iii) a new mission module which would be deployed singly or in combinations of two or more for use as space stations in earth and lunar orbit or as a lunar surface base. A principal assignment of the space stations would be to test man's ability to endure prolonged space flight, though the psychological conditions astronauts would experience when committed irretrievably to a 2-year Mars mission could not be simulated.

According to NASA, basically the same module, space shuttle, and tug would be used and reused in a variety of missions, thus bringing the cost of space operations down drastically. By the late 1970's, a reusable nuclear shuttle, for which the propulsion system is already under development in the Nerva rocket project, would come into use, first in an expanding program of lunar exploration but later for any mission involving heavy payloads and great distances. This and the other new systems of the 1970's would support the ambitious ventures NASA is proposing for the 1980's, of which a manned landing on Mars is only one.

Another is the large space base that would be established in earth orbit for the support of up to 100 persons. This base, an evolutionary offspring of the earlier orbital workshops and space stations, would be made up of a number of modules joined together, each representing separate units of activity. The various activities at the space base would include such things as astronomical observation, research in physics and biology, the surveying of earth resources, and materials research and processing under conditions of zero gravity. The availability of the nuclear shuttle would allow still another big step, the establishing of a large manned station in geosynchronous orbit some 22,000 miles above the earth.

Leap across the Threshold

But, in the NASA vision, the culminating event of the 1980's would be the landing on Mars, marking man's leap across the threshold into an era of planetary travel and exploration. NASA insists that this leap need not be taken in the dark. Construction of the Mars excursion module, the major piece of equipment peculiar to the mission, would not have to start until some 6 years before the flight. Meanwhile, the results of two automated Mars missions, the Mariner Orbiter of 1971 and the Viking mission of 1973 (in which experiment packages would be dropped to the Martian surface) would be providing information bearing on the question of whether Mars is a safe and worthwhile place to go. "I see no reason to make the commitment [to go to Mars] until after Mariner Orbiter and Viking," Paine said in an interview with *Science*.

The Integrated Program concept, whatever its other merits, is politically shrewd, for some congressional leaders already have made it clear that, however President Nixon may feel, they are not willing for NASA to plunge precipitously into a manned Mars landing program. Even the chairman of the House space committee, Representative George P. Miller of California, recently has said that it is not yet time to set sail for Mars. But Miller then went on to recommend rapid progress toward a set of goals closely resembling those of the Integrated Program.

Newell, NASA's associate administrator, says that among the scientists with whom the agency deals there is a "remarkable unanimity" of opinion in support of its plans—except with respect to the fast pace of development

NEWS IN BRIEF

• **NIH GRANTS CUT BY 20 PERCENT**: The National Institutes of Health (NIH) has reduced by approximately 20 percent the overall funding level for its continuing research grants due for renewal on 1 September, in response to the Administration's urging that federal agencies cut back their spending levels. NIH officials seemed reluctant to say whether cuts would be made across-the-board or on a selective basis, but it appears that the percentages of the individual cuts may vary. Scientists regard the 20 percent cut as particularly serious since research costs have risen rapidly over the last few years. The reduction, which represents a tentative planning figure, affects both individual competing and noncompeting NIH continuing grants. Last year, NIH held back about 15 percent of its overall support for research, and later restored about 7 or 8 percent of the negotiated reduction. NIH officials say that a restoration of part of the reduced funding may be repeated again this year. NIH's freeze on new grants, effective since July 1969, will persist until the Administration determines HEW's fiscal 1970 spending level.

• **SUBMARINE MISSION COMPLETED**: Six scientists and engineers led by Swiss oceanographer Jacques Piccard have completed the first submerged drift through the Gulf Stream, off the east coast of the United States. After logging 1600 miles in 30 days, the crew of the research submarine *Ben Franklin* reported several surprises, including a scarcity of sea life below the surface. Few schools of large fish were discovered, and, contrary to Piccard's expectation, no deep scattering layers (the shifting layers of plankton and other marine organisms that reflect sonar pulses in most ocean areas) were found. The crew also discovered that the undersea current could propel the *Franklin* at speeds of 3 to 4 knots—twice as fast as had been predicted. Contributing to the research effort, NASA provided a crew member to evaluate the ship's life-support system and cabin design for possible application in the manned-space-station program. NASA and the Navy Oceanographic Office contributed $160,000 to the project, and the Grumman Aircraft Engineering Corporation spent $5.3 million.

Hurricane Seeding: A Quest for Data

Cloud-seeding operations on the recent hurricane Debbie in the Atlantic were called a failure in some press reports, which implied that the purpose of the seeding was to reduce the storm's intensity and its potential for destruction. Pained weather scientists involved in the seeding operation deny this. R. Cecil Gentry, director of the National Hurricane Research Laboratory in Miami and head of Project Stormfury, which carried out the seeding program, says the purpose of the seeding operation was to acquire data on the nature of and changes in hurricane structure and position, rather than to modify or destroy the force of a specific storm. He says the cloud seeding project was "an operational success."

On 18 and 20 August, the Department of Defense and the Environmental Science Services Administration (ESSA), the two principal federal groups participating in Project Stormfury, seeded the eye wall of hurricane Debbie, about 460 to 650 miles off of San Juan, Puerto Rico, with a ton of silver iodide crystals. The seeding of hurricane Debbie was the first attempt at multiple seeding of hurricane clouds. The cumulus clouds surrounding the hurricane eye wall were seeded five times at 2-hour intervals each day to determine whether their modification would cause a measurable change in the hurricane itself. Theoretically, injection of silver iodide particles into the hurricane clouds should transform supercooled water droplets into ice crystals. This transformation should result in a sudden release of the latent heat of fusion of the droplets. If injected into proper areas of a hurricane, the heat may cause redistribution of the storm's energy and a reduction in maximum wind velocities.

Gentry estimates that it will take 2 or 3 months to evaluate the large amount of recorded film and magnetic tape that was collected in the cloud-seeding operation. Gentry told *Science* he is reluctant to predict the results of the seeding of hurricane Debbie. Minor changes, he said, were observed in the structure of the clouds and in the storm's mechanisms, but he declined to attribute these changes directly to the seeding operation. "The changes were of a type that could have occurred naturally, so I'm cautious about setting up any cause-and-effect relationships," he said.

Project Stormfury, an interdepartmental project that costs an estimated $500,000 annually, began full operation in 1962 to study means of hurricane modification by cloud seeding. Today seeding is authorized in the southwestern Atlantic, the Caribbean Sea, and the Gulf of Mexico. Since the program began, experiments have been performed on only two major storms—hurricane Esther in 1961 and hurricane Beulah in 1963—and no definite conclusions were drawn from either experiment. "We have some clues, but no real answers," Max William Edelstein, a Navy technical adviser assigned to the project, said. Edelstein said that a hurricane, to qualify for seeding under Project Stormfury, must have a well-defined eye, winds better than 75 miles per hour, and a location where the probability is small—10 percent or less—that the hurricane will come within 50 miles of a populated area during the ensuing 24 hours. These three requirements are not always met in a single hurricane. A case in point is Camille—the hurricane that holds the all-time record for strong winds affecting the U.S. mainland—which hit the Gulfport, Mississippi, coastal area in August at speeds of 190 miles per hour. Camille was not seeded because it was predicted to be within 24 hours of land at all times.

Scientists concede that research on hurricane modification is still in the early stages, and that no one is yet sure whether man can significantly change a hurricane's direction or force with seeding techniques. A major obstacle in determining whether cloud seeding is an effective means of modifying hurricanes is that nature has not provided many hurricanes of a size, position, and velocity suitable for experiment.

—MARTI MUELLER

proposed. On this matter of timing, Newell says, is "where we part with the scientific community. They say that if we get locked into this large technological program, with the unforeseen technical and budgetary problems that may arise, we will say, 'Mr. Science, Mr. Applications, you wait a little while. We'll get to you later.' This is what the scientists are apprehensive about." The apprehensiveness is no doubt a carry-over from the attitude many scientists held toward Apollo, which they viewed as having too little merit, scientifically or otherwise, to justify its high ($24 billion) cost. The Integrated Program culminating in a Mars landing would cost more than twice as much as Apollo.

A few months ago, the Academy's Space Science Board, chaired by Harry H. Hess of Princeton (who died of a heart attack on 25 August), wrote to DuBridge about the question of a manned flight to Mars. This letter's contents have not been divulged, but apparently the board recommended that no new Apollo-type program, with development tied to a fixed and fast-paced schedule, be undertaken. Yet the letter seems to have been worded vaguely enough to allow for a wide latitude of opinion among the board members.

For example, two of those whom *Science* interviewed, Wolf Vishniac of the University of Rochester and Luis W. Alvarez of the Lawrence Radiation Laboratory, said that they are largely in agreement with NASA's Integrated Program plans. Vishniac says that the NASA budget should be allowed to rise gradually from its present level of less than $4 billion to between $5 and $6 billion (according to Newell, if NASA is to attempt a manned Mars mission in the early 1980's, the agency budget would have to be increased to between $7 and $8 billion a year by the end of the 1970's).

However, Gordon J. F. MacDonald of the University of California at Santa Barbara, who is also a member of the board, says that for the next few years a space budget of $2½ to $3 billion would be adequate. This would allow NASA to carry on good planetary and space applications programs and to retain its existing manned flight capability long enough to determine whether man really does have a useful role to play on space missions, MacDonald says. "My intuitive feeling is that it [man's role] is going to be very limited," he adds.

Bruce Murray of the California Institute of Technology, a geologist who has taken part in NASA's automated flyby missions to Mars, also is not ready to say that man has a role to perform on planetary missions that cannot be handled better and more cheaply by robots. "If manned planetary exploration is to be a genuine endeavor," he says, "man must perform an important function in a mission of enormous exploratory potential. At present we have not identified that function or that mission."

In reply, NASA's Administrator Paine, who is no shy advocate, says that to believe man is not going to explore space is "very unrealistic." Man will, he observes, go into space partly for scientific reasons, but also because the moon and the planets are places of intense fascination. Those who question this, he adds, display an attitude typical of the middle-aged who always say "You're not going to get me up in one of those things."

"By the end of the century," Paine says, "if you haven't been to the moon, you're not going to be with it." In Paine's view, poverty must be eliminated, but the United States' vast educational effort should have some purpose higher than of qualifying the nation "to fill 200 million alimentary canals every day." One high purpose, he adds, is to make the earth a mere "chip of rock" in the heavenly void, a base for exploring the vast reaches of the solar system. "Our space program of the 1970's is to bring this day nearer," he says. While conceding that it would indeed be possible to stretch out achievement of the Integrated Program over a longer period, he says that this would involve major drawbacks. The stretch-out would make the program ultimately cost far more, he explains, and it would transform NASA from an "organization of young men in a hurry to an organization of old men enjoying the leisurely pace of their work."

In trying to assess NASA's future prospects, one must remember that the Soviet Union remains a competitor in space and that NASA's manned flight program continues to be regarded as a safeguard against "technological surprise." The Nixon Administration's recent cancellation of the Air Force's Manned Orbiting Laboratory (MOL) program indicates that, insofar as there is a military requirement for man in space, the basic capabilities and hardware will be developed through NASA's Integrated Program (though Paine says NASA will remain an open, civilian-oriented agency).

Even though predicting the decisions of the President and the Congress is risky, one may guess that NASA, as a going organization which has just demonstrated an extraordinary competence in Apollo, will find its proposals treated kindly. To the plans for the Mars venture, the verdict is less likely to be Yes than Maybe, but NASA expects this. And if the pace of development allowed for its Integrated Program is not quite so brisk as it would like, the agency knows that Mars will still be out there.—LUTHER J. CARTER

Lead Poisoning: A Preventable Childhood Disease of the Slums

Lead poisoning was once an occupational disease commonly associated with painters, devotees of moonshine liquor, and an occasional curious child. But lead as a health hazard has come under increasing scrutiny. New York City once averaged 500 cases of lead poisoning a year; the City Health Department now estimates that a "silent epidemic" of lead contamination may be affecting as many as 25,000 slum children, who pick up the lead from chipping leaded paint in old buildings. Lead poisoning has sparked local political skirmishes and suggestions for increasing federal regulations and aid.

The diagnosis of classical lead poisoning includes a high blood content of lead, plus convulsions, vomiting, anemia, and cramps—external symptoms that can be readily confused with those of other, less dangerous illnesses if a physician is not looking specifically for lead. In severe cases, the marrow and central nervous system can be damaged, and death or mental retardation can result. Since lead often accumulates slowly over a period of months, a child can carry a dangerously high level of lead without exhibiting any of the external symptoms. No one is quite certain how widespread lead poisoning is, but the number of U.S. children with abnormally high blood levels of lead may be as high as 225,000. Children accumulate the lead by eating nonfood objects, such as chips of leaded paint, even if they are not hungry—a phenomenon known as "pica" (a reference to the magpie and its indiscriminate eating habits).

Since the 1940's, leaded paint has been replaced by cheaper, titanium-dioxide-based paints, and many localities have banned the use of leaded paint for interior surfaces. But in some older cities where, in the poorer sections, many house walls have peeling coats of old leaded paint, several studies have indicated that some 5 to 10 percent of children between the ages of 1 and 6 have abnormally high blood levels of lead.

Once a lead-poisoning case is detected, the child is usually hospitalized for several days and treated with chelating agents—chemicals that bind the lead ion and remove it from body tissue. These chelating agents include BAL, an anti-nerve-gas drug, and EDTA, a chemical familiar in biochemical research. Before chelation therapy was developed, 66 percent of severe lead poisoning cases were fatal, said J. Julian Chisholm, associate professor of pediatrics at Johns Hopkins Medical School. With early detection and treatment, this figure has probably dropped to less than 5 percent, he added.

But of the survivors, brain damage still occurs in more than 25 percent of the children. After returning home from treatment, children often resume their paint-eating habits, and if they again come down with lead poisoning, the risk of permanent brain damage increases to "virtually 100 percent," Chisholm said.

"After treatment they become complete vegetables," said Hyman Merenstein, associate professor of pediatrics at the