

A number of problems may well arise in the National Booster Program. The present Mercury program, based on the Atlas, is marginal and if the Atlas proves inadequate for the job it may be necessary to push alternatives vigorously. The first possibility appears to be the Titan, although it has not yet demonstrated the reliability which is required. We should study the desirability of carrying out a Titan-boosted Mercury program in the event Atlas should prove to be inadequate.

The Centaur rocket involves an entirely new technology and is still untested. If difficulties develop in this program within the next three or four months we must act promptly to initiate an alternate.

Development of the Saturn-boosters—a cluster of eight Atlas engines—should continue to be prosecuted vigorously. However, it would be dangerous to rely on Saturn alone for the solution to our problems, either in the long or short term, for two reasons:

(a) It is intrinsically so complex that there is a real question whether it can be made to function reliably.

(b) It represents a maximum elaboration of present technology and provides no route to further development.

Therefore, the development of a very large single engine should proceed as fast as possible so that it may be a back-up for the Saturn cluster and a base for future larger vehicle development. The present F-1 (1.5 million lb. thrust) engine development should be studied to be sure it is progressing fast enough and has enough promise of success to fill this role. If the technological step in going from the present 180,000 lb. thrust engines to 1.5 million lbs. is so big as to make success marginal, a parallel development of a somewhat smaller engine should be started.

The nuclear rocket program (Rover) presents an area in which some major decisions will have to be taken by the new administration. In principle the nuclear rocket can eventually carry heavier payloads much farther than any chemical rocket. Nevertheless, the technology is so new and the extrapolation from reactors developed now to sizes which would be useful in large rockets is so great that it is not clear how soon they will make an important contribution to the space program. The use of nuclear rockets will raise serious international political problems since the possibility that a reactor could reenter and fall on foreign territory cannot be ignored. A major technical and management review of the Rover program seems urgent.

Above all we must encourage entirely new ideas which might lead to real breakthroughs. One such idea is the Orion proposal to utilize a large number of small nuclear bombs for rocket propulsion. This proposal should receive careful study with a realization of the international problems associated with such a venture.

#### *V. Science in Space and Space Exploration*

In the three years since space exploration began, experiments with satellites and deep space probes have provided a wealth of new scientific results of great significance. In spite of the limitations in our capability of lifting heavy payloads, we now hold a position of leadership in space science. American scientists have discovered the great belt of radiation, trapped within the Earth's magnetic field. American scientists have revealed the existence of a system of electric currents that circle our planet. Our space vehicles have probed the interplanetary space to distances of tens of millions of miles from the Earth. They have shown that the Earth is not moving through an empty space but through an exceedingly thin magnetized plasma. They have intercepted streams of fast-moving plasma ejected from the Sun which, upon reaching our planet, produce magnetic storms, trigger off auroral displays and disrupt radio communications.

From these and other experiments, there is gradually emerging an entirely novel picture of the conditions of space around our planet and of the Sun-Earth relations. One of the important tasks of space science in the next few years will be a full exploration of the new field revealed by the early experiments. There is little doubt that such exploration will lead to further important discoveries.

Another scientific field, where space science promises an early and major breakthrough is that of astronomy. Until a few years ago, visible light from celestial objects, reaching our telescopes through the atmospheric blanket, had been the only source of astronomical information available to man. The only other portion of the spectrum capable of penetrating the atmosphere and the ionosphere is that corresponding to shortwave radio signals. In recent years, the development