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Death of a Project

Research is stopped on a system of space propulsion which broke all the rules of the political game.

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In January 1965, unnoticed and unmourned by the general public, Project Orion died. The men who began the project in 1958 and worked on it through 7 strenuous years believe that if offers the best hope, in the long run, of a reasonable program for exploring space. By "a reasonable program" they mean a program comparable in cost with our existing space program and enormously superior in promise. They aimed to create a propulsion system commensurate with the real size of the task of exploring the solar system, at a cost which would be politically acceptable, and they believe they have demonstrated the way to do it. Now the decision has been taken to follow their road no further. The purpose of this article is neither to bury Orion nor to praise it. It is only to tell the public for the first time the facts of Orion's life and death, and to explain as fairly as possible the political and philosophical issues which are involved in its fate.

Vehicle Design and Capabilities

First, a brief technical summary. Orion is a project to design a vehicle which would be propelled through space by repeated nuclear explosions occurring at a distance behind it. The vehicle may be either manned or unmanned; it carries a large supply of bombs, and machinery for throwing them out at the right place and time for efficient propulsion; it carries shock absorbers to protect the machinery and the crew from destructive jolts, and sufficient shielding to protect against heat and radiation. The vehicle has, of course, never been built. The project in its 7 years of existence was confined to physics experiments, engineering tests of components, design studies, and theory. The total cost of the project was $10 million, spread over 7 years, and the end result was a rather firm technical basis for believing that vehicles of this type could be developed, tested, and flown. The technical findings of the project have not been seriously challenged by anybody. Its major troubles have been, from the beginning, political. The level of scientific and engineering talent devoted to it was, for a classified project, unusually high.

The fundamental issue raised by such a project is: Why should one not be content with alternative means of propulsion which are free from the obvious biological and political disadvantages of nuclear explosions? The answer to this question is that, on the purely technical level, an Orion vehicle has capabilities which no other system can approach. All alternative propulsion systems which we know how to build are either temperature-limited or power-limited. Conventional rocket systems, whether chemical or nuclear, are temperature-limited in that they eject gas at a velocity V limited by the temperature of chemical reactions or of solid structures. The upper limit for V appears to be about 4 kilometers per second for chemical rockets, 8 kilometers per second for nuclear rockets. For missions involving velocity changes many times V, multiple-staged rockets are required, and the initial vehicle size needed in order to carry a modest payload soon becomes preposterous. The initial weight is *multiplied* by about a factor of 3 whenever an amount V is *added* to the velocity change of a mission. It is for this reason that programs based on conventional propulsion run into a law of heavily diminishing returns as soon as missions beyond the moon are contemplated.

The other class of propulsion systems at present under development is the so-called nuclear-electric class. These systems use a nuclear reactor to generate electricity, which then accelerates a jet of ions or plasma by means of electric or magnetic forces. The velocity of the jet is no longer limited by considerations of temperature, but the available thrust is limited to very low values by the power of the electric generator. Vehicles using nuclear-electric propulsion necessarily accelerate very slowly and require long times to achieve useful velocities. They have undoubtedly an important role to play in long-range missions, but they offer no hope of transporting men or machines rapidly around the solar system.

The Orion propulsion system is neither temperature-limited nor power-limited. It escapes temperature limitations because the contact between the vehicle and the hot debris from the explosions is so brief that the debris does no more than superficial damage. It escapes power limitations because the nuclear engine (bomb) is outside the vehicle and does not depend on coolants and radiators for its functioning. An Orion vehicle is unique in being able to take full advantage of the enormous energy content of nuclear fuel in order

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to achieve, simultaneously, high exhaust velocity and high thrust.

Let me give an example of the specific performance that would be achieved by first-generation Orion vehicles. Designs were worked out in detail for vehicles that could carry eight men and a payload of 100 tons on fast trips to Mars and back. The vehicles were small enough to be lifted into space by Saturn chemical rockets, and the cost of the Saturn boosters turned out to be more than half the estimated cost of the whole enterprise. These designs do not, of course, prove that a manned expedition to Mars is a worthwhile undertaking; they indicate only that if you wish to go to Mars, then Orion will take you there more rapidly and cheaply than other vehicles that are now being developed.

So much for the technical background of Orion. Next comes the political history. The idea of a bomb-propelled vehicle was first described by Ulam and Everett in Los Alamos in 1955. It was transformed into a serious and practical proposal by a group of physicists and engineers at General Atomic Division of General Dynamics Corporation in San Diego, under the leadership of Theodore Taylor. Work at General Atomic started in the spring of 1958, as a direct response to the first Sputniks. The initial group at General Atomic, including Taylor, were old weaponeers from Los Alamos, and they seized happily upon this opportunity to make their knowledge of nuclear explosions serve a loftier purpose than weaponry. Within a few months they had worked out the basic theory of the Orion system, and found that it worked even better than they had supposed.

Government Sponsorship

The problem then arose of obtaining government sponsorship and money for the project. The National Aeronautics and Space Administration (NASA) did not yet exist. There was only one government agency which could logically take responsibility and fund the project —namely, the Advanced Research Projects Agency (ARPA) of the Defense Department. It was a thoroughly anomalous situation to have a group of weapons experts in a private company working on a space project, and it took many months of negotiation to obtain the first contract from ARPA. At that early date in its history ARPA did not insist that anything which it supported must have a military justification. The terms of the first contract permitted designation of peaceful interplanetary exploration as the major goal of the project. Nevertheless the project was administered through Defense Department channels, and military influences were inevitably at work upon it.

Quite soon after Orion officially began, NASA was established, with legal responsibility for all nonmilitary space activities. NASA quickly began to annex parts of ARPA's nonmilitary functions, and the Air Force responded by annexing ARPA's military space projects, so that the situation of ARPA was reminiscent of the partition of Poland between Prussia and Russia in the 18th century. In the end, Orion was left as the only space project in the hands of ARPA, largely because neither NASA nor the Air Force considered it a valuable asset. Taylor's efforts to interest NASA in Orion during this period met with no success.

In 1960 ARPA decided to drop Orion, and Taylor was compelled to go to the Air Force for sponsorship. According to the law, the Air Force may handle only military projects, and must apply a rigid definition of the word *military*. A project is defined as military only if a direct military requirement for it exists. There is no military requirement for interplanetary exploration. Thus Taylor paid a high price for his Air Force contract. Although the technical substance of the work was not changed, the project became in name a military enterprise directed toward real or imagined military requirements. This arrangement continued in force until the end of the project in 1965.

The effect of the military sponsorship of Orion was, in the end, disastrous. The Air Force officials administering the project were sympathetic to the long-range and nonmilitary aspects of the work, but they were compelled by their own rules to disguise their sympathies. Each year when they applied to the high authorities in the Defense Department, Harold Brown and McNamara, for more money to expand the project, they had to argue in terms of immediate military requirements. Men as wise and critical as Harold Brown and McNamara could easily see that the military applications of Orion are either spurious or positively undesirable. So the requests for expansion were turned down. The Air Force was told that if it wished to continue the project for nonmilitary reasons it should enlist the cooperation of NASA.

In 1963 NASA finally showed some official interest in Orion. Jim Nance, acting first as assistant director of the project under Taylor and later as director in his own right, established friendly relations with the Marshall Space Flight Center in Huntsville, Alabama. Within NASA, Orion's possibilities appealed particularly to the Office of Manned Space Flight, where people are beginning to worry about what they should do after the Apollo mission is over. NASA awarded Orion a small study contract, and from this resulted the design of ships for specific interplanetary missions. Also in 1963 the test-ban treaty was signed, and nuclear explosions became more than ever politically questionable.

In 1964 the shadows began to close in. The Air Force grew tired of supporting a project which McNamara would not allow to grow, and announced that further support would be forthcoming only if NASA would make a serious contribution. At the eleventh hour, in October 1964, Nance succeeded in getting the basic technical facts concerning Orion (*1*) declassified, so that it became possible for the first time to discuss the issue publicly. A certain interest in Orion belatedly developed within the engineering community but did not extend to the scientific community. In December 1964 the question of the support of Orion came to a final decision within NASA, with the result which was announced in January 1965.

Concerning the Verdict

As is proper in conducting an inquest, we have first assembled the historical evidence, and now we come to the question of a verdict. Who killed Orion, and why? And was the murder justifiable?

Four groups of people were directly responsible for the death of Orion. These are the Defense Department, the heads of NASA, the promoters of the test-ban treaty, and the scientific community as a whole. Each group encountered Orion within the context of a larger struggle in which Orion appeared to them as a relatively minor issue. In each group a negative attitude toward Orion was dictated by general principles which, in the wider context,

were wise and enlightened. In each group the men who killed Orion acted from high and responsible motives. And yet their motives were strangely irrelevant to the real issues at stake in this highly individual case. I will examine the four groups in turn and describe how the problem of Orion presented itself to them.

The Defense Department chiefs have been waging for many years a successful battle to stop the Air Force from embarking upon a great variety of technically interesting projects whose military importance is questionable. The nuclear-propelled airplane was one such project, which was stopped only after large sums of money had been wasted on it. More recently, as in the cases of the B-70 bomber and the Dynasoar orbital airplane, McNamara has been strong enough to call a halt before the big money was spent. There is little doubt that, when the Air Force asked for more money for Orion, the authorities in the Defense Department mostly thought of it as one more in the long series of Air Force extravaganzas which it was their duty to suppress. The way in which the money was requested made it difficult for them to view it otherwise. And within this context their decision was unquestionably right.

The heads of NASA were not interested in Orion at the time NASA began for the simple reason that it was a classified project supported by the Defense Department and therefore outside their terms of reference. They were explicitly enjoined by Congress not to trespass upon military ground, and they had no wish to become gratuitously involved with a project encumbered by all the bureaucratic nuisances of secrecy. The established policy of NASA is to conduct as many as possible of its operations openly and without requiring all its employees to be cleared for security. Few will question that this policy is wise as a general rule, and indeed essential to the maintenance of a healthy scientific atmosphere within NASA.

When the heads of NASA came to their final decision concerning Orion, in 1964, the jurisdictional issue was no longer central. The Air Force had officially appealed to NASA for a declaration of support, and participation in a future development of Orion would not have compromised the nonmilitary status of NASA. In 1964 the dominating concern at the top levels of NASA was the search for political stability. The heads of NASA have learned that their first duty to the space program is to keep it politically popular. Without consistent support from the public and from Congress, there would be no possibility of an effective program. It is therefore wise to sacrifice technical improvements if technical improvements carry risks of failure which may be politically upsetting to the entire program. Above all, spectacular and public failures are to be avoided. When a responsible public official thinks of Orion he inevitably envisions a shipload of atomic bombs all detonating simultaneously and wiping out half of Florida. Though it is technically easy to make such an accident impossible, it is not possible to exorcise the fear of it. The heads of NASA know that fear is the most potent force in politics, and they have no wish to be feared.

The promoters of the test-ban treaty are a heterogeneous group of people, including the Arms Control and Disarmament Agency, the State Department, a large segment of Congress, the White House staff, and the President's Science Advisory Committee (PSAC). About the only thing that all the people working for the treaty had in common was a total unconcern for the welfare of Project Orion. Most of them had never heard of Orion, and most of those who had heard of it (for example, some influential members of PSAC) had met it only in a context in which they were committed to oppose it. They had met it within the context of a continuing battle to stop the military arm of the U.S. Government from gratuitously expanding the arms race into arenas where no arms race yet existed. The PSAC had been successful in opposing a race to build bigger bombs than the U.S.S.R. was building, and had also successfully opposed the idea of placing offensive nuclear weapons in orbit. The members of PSAC have developed a deep commitment to the policy of military restraint, of deploying new weapons systems only when a military need exists and not just for the sake of technological novelty. Their commitment to this goal has served their country well, and has borne fruit in many other wise decisions besides the decision to negotiate the test-ban treaty. Seeing Orion from this viewpoint, as an Air Force project ostensibly aimed at large-scale military operations in space, they felt no qualms in crushing it.

Lastly, the scientific community as a whole is responsible, in a negative sense, for the death of Orion. The vast majority of scientists have consistently refused to become interested in the technical problems of propulsion, believing that this was a job for engineers. A clear illustration of their point of view is provided by the report on national goals in space for the years 1971–85, recently published by the Space Science Board of the National Academy of Sciences. This report describes in detail a recommended program of space activities which is based on the assumption that the propulsion systems available until 1985 will be those now under development. The Space Science Board does not concern itself with the question of whether a scientific effort might bring radical improvements in the art of propulsion before 1985. To somebody familiar with the potentialities of Orion, the Space Science Board program seems both pitifully modest and absurdly expensive.

Here again, the disinterest of scientists in problems of propulsion arises from attitudes which in a wider context are wise and healthy. In their dealings with NASA and with the public, scientists have constantly preached that the payload is more important than the rocket, that what you do there is more important than how you get there. They have argued repeatedly, and usually without success, that ten dollars spent on unmanned vehicles are scientifically more useful than a hundred spent on manned vehicles, and that often one dollar spent on ground-based observations is scientifically more useful still. They have been alienated from the field of propulsion by the spectacle of NASA officials claiming a scientific justification for space-propulsion developments which have little or nothing to do with science. They have, after long years of listening to the pseudoscientific propaganda of the manned space program, learned to confine their attention to that small part of the NASA empire within which they have some real influence—namely, the Office of Space Science and Applications (OSSA). Within OSSA they have created an atmosphere of scientific sanity which has allowed excellent and many-sided programs of unmanned scientific exploration to be carried out with the eighth of the NASA budget which is allotted to this purpose.

The Space Science Board of the National Academy, in its consideration of future activities, was mainly concerned with preserving the quality and the sci-

entific integrity of these existing unmanned programs. The board rightly sees as its primary task the definition of the ends, rather than the means, of the space science enterprise.

What then is the attitude of a scientist who is actively engaged in scientific space activities toward a project such as Orion? He has perhaps just been denied by NASA a half-million-dollar ground-based telescope with which to observe planets. Or he has designed an experiment which was excluded, because of space limitations, from the next orbiting solar observatory. And then he hears that a wonderful new propulsion system has been invented which might allow him, 15 years later, to make high-quality nearby observations of Jupiter and Saturn. The price of the new system is quoted as only a few billion dollars. He is understandably not enthusiastic.

This brief summary of Orion's history has shown that every one of the four murderers had good and laudable motives for killing the project, or, in the case of the scientific community, for not lifting a finger to save it. Orion had a unique ability to antagonize simultaneously the four most powerful sections of the Washington establishment. The remarkable thing is that, against such odds, with its future never assured for more than a few months at a time, the project survived as long as it did. It held together for 7 long years a band of talented and devoted men, and produced in that time a volume of scientific and engineering work which in breadth and thoroughness has rarely been equaled.

The story of Orion is significant, because this is the first time in modern history that a major expansion of human technology has been suppressed for political reasons. Many will feel that the precedent is a good one to have established. It is perhaps wise that radical advances in technology, which may be used both for good and for evil purposes, be delayed until the human species is better organized to cope with them. But those who have worked on Project Orion cannot share this view. They must continue to hope that they may see their work bear fruit in their own lifetimes. They cannot lose sight of the dream which fired their imaginations in 1958 and sustained them through the years of struggle afterward—the dream that the bombs which killed and maimed at Hiroshima and Nagasaki may one day open the skies to mankind.

Reference

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Conformity as a Tactic of Ingratiation

Uses of agreement to enhance one's power in a social relationship are explored experimentally.

Edward E. Jones

There seems to be much promise in looking at social interaction with an eye to the unfolding of strategies designed to gain or maintain personal power. There is nothing novel in the suggestion that there is a strategic side to social behavior—that people try to calculate ways to make the most of a particular relationship—but the attempt to study such strategies by laboratory experimentation is a recent development. Here I shall review several studies which especially concern ingratiation, or "strategic behaviors . . . designed to influence a particular other person concerning the attractiveness of one's personal qualities" (*1*). I hope, in the process, not only to present results relevant to a developing theory of strategic overtures, but also to illustrate a form of experimental research which seems to show promise of unraveling the subtleties of social behavior.

All interpersonal relationships involve mutual dependence; this is the equivalent of saying that each party to a social interchange has potential influence over certain rewards available to and costs incurred by the other. If the dependences of one on the other are not only mutual but approximately equal, then there is a balance of power in which each can enforce a certain minimal receipt of rewards through his capacity to enact or fail to enact the responses sought by the other. When the power in a two-person relationship is asymmetrical, however, the more dependent person is somewhat at the mercy of the more powerful one. In any event, we can well understand why the more dependent person is concerned about his poor position and, under most circumstances, tries in various ways to improve it.

When we look at the strategic alternatives available to the more dependent person, it appears that some of these strategies guarantee him at least a certain minimum of rewards but do so at the expense of confirming or strengthening the power asymmetry which defines his dependence. Other strategies, however, may be effective in modifying the asymmetry itself so that the dependent person's power is, in the long run, increased. Compliance is an example of one kind of dependence-confirming tactic. The dependent person may, through overt obedience, avoid punishment and secure the rewards available to him, but such compliance tends to perpetuate the power differential to which it is a response. For example, the more reliable the worker becomes in meeting the supervisor's demands, the more confident the supervisor will be that these demands are reasonable, and that the worker is happy with the "bargain" symbolized by the difference in their

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