N64-30346

GOVERNMENT AND INDUSTRY

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During the previous sessions, attention has been centered primarily on scientific and technical aspects of the space program. Today we are taking up subjects that are less glamorous, but certainly just as deserving of our best thought and effort. Maintaining and improving the close cooperation of government, industry, and the scientific community is a primary concern essential to mission success.

Almost every project NASA has undertaken during the past 5½ years has been characterized by newness and innovation. In many ways the space program has been without precedent. It is, therefore, not surprising that along with our efforts to solve the problems of space exploration, we have found it necessary to devote a great deal of study to determining the best ways of managing a program of this scope.

In our early efforts to overtake the lead of the Soviet Union and gain preeminence in space, we had to form an organization and draw together a number of separate organizations and programs.

To accomplish this, NASA from the start has continually appraised its organizational structure and management methods. We have made every effort to meet the needs for change as they have arisen. Problems have never been permitted to pile up to the point where a major overhaul or massive reorganization was required in order to get on with the mission.

NASA PROGRAM

This is not the time nor the place to go into a lengthy discussion of the changes made over the years in NASA's internal structure. In brief, our philosophy is to limit our inhouse activity—except for a relatively small amount of research for which existing Government laboratories have a special competence—to supervising, integrating, and administering our contracts with industry, universities, and private research organizations.

The discussions of this conference so far divide easily into four general areas:

1. Manned Space Flight
2. Space Science and Applications
3. Advanced Research and Technology
4. Tracking and Data Acquisition.

Manned Space Flight Program

The Manned Space Flight program has as its objective the exploration and utilization of space by man. Steps toward this goal involve the development of a capability for extending stay times in space, the development of techniques for rendezvous and docking in space, and the capability for landing men on the Moon and returning them safely to Earth by the end of this decade. Integral with this program is the development of new and powerful large launch vehicles with the associated capability for constructing, testing, and launching these vehicles and their complex manned payloads. This has been and will continue to be a difficult program, but one which we have every confidence of being able to accomplish.

Space Science and Applications Program

In the Space Science and Applications program, we are interested in developing our understanding of the Earth and the space about it, our solar system, our galaxy, neighboring galaxies, and the interplanetary space; in this program we are producing the technology that provides the basis for the commercial development of operational space systems such as weather and communications satellites. We are studying the Moon, the Sun, and the nearby planets. Investigations of the nearby planets include efforts to determine the existence and possible forms of life on their surfaces. The program also examines the effects of space environment on terrestrial forms of life.

Advanced Research and Technology Program

The prime objective of the Advanced Research and Technology program is the provision of a broad, sound, technical base for this Nation's future aeronautics and space activities. Much of this effort is conducted within Government, university, and NASA laboratories. However, some flight projects are required to support the laboratory program. The fields of interest range from propulsion to spacecraft, aircraft, and human factors.

Tracking and Data Acquisition Program

The Tracking and Data Acquisition program supports all the manned and unmanned missions of NASA. Its worldwide operation is an essential element of the total NASA program. It is obvious that from the space and aeronautics missions little will be gained unless useful data are returned to our engineers and scientists.

PROGRAMING CONCEPTS

We use the term *programing* in NASA to cover the total process of establishing goals, breaking these goals down into specific feasible missions, phasing these missions in such a way as to take maximum advantage of each mission's results in terms of subsequent missions, and applying appropriate emphasis to these missions in terms of the country's and NASA's total available resources.

An examination of our scientific objectives in space shows that a key element is the collection and evaluation of data and information. This collection and evaluation is a cyclic process (fig. 1). Gaps in man's knowledge, whether in terms of basic natural phenomena or in methods and techniques, excite possible theories based on knowledge already available. Substantiation of a new scientific concept must be based on flight experimentation. In other words, a theory on the origin of the Moon must be translated into measurable facts which support or deny that theory. The measuring instrumentation is carried aboard spacecraft designed for space-flight missions. The actual data, once collected, must be returned to Earth and thence to the experimenters who originated the theory and often developed the measuring instrument. A comparison of the anticipated and actual data permits either validation or rejection of the theory.

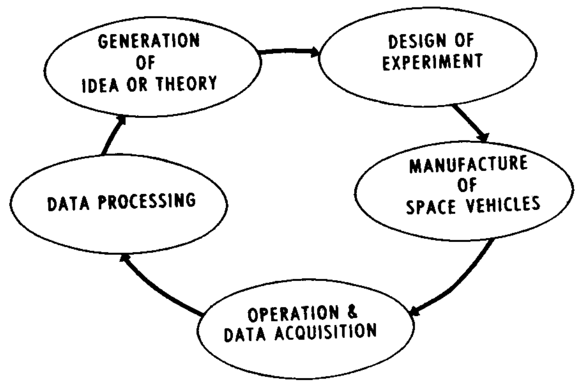

FIGURE 1.—Project cycle.

The advancement of technological developments for space operations follows the same type of cyclic process. Theoretical concepts are derived in Government, university, and industrial laboratories for modified or new types of propulsion, power, stabilization, guidance, communications, life support, structures, and reentry techniques that might lead to improved launch-vehicle and spacecraft capability. Experimental models are designed, fabricated, and tested to prove or disprove the concept. Oftentimes this requires extensive ground-based facilities such as wind tunnels, shock tubes, and space chambers. Ultimately, as in the attainment of scientific objectives, flight tests are required to confirm or deny the theoretical and laboratory results.

The entire cycle for both scientific investigation and technology advancement takes an extended period of time because it includes the design and fabrication of spacecraft, launch vehicles, tracking and data acquisition systems; and development of computing and analysis techniques. The new can build on the old only at a given pace, and to force that pace or interrupt it can be extremely damaging to the orderly and economic prosecution of our space program.

There are three variable factors that must be continuously considered in the management of our programs, namely, performance, cost, and time. It is possible to affect any one of these at the expense of the others. We make every effort to attain required performance within our budgetary authorization. We must take the time to conceive, design, build, and test experiments of excellent quality and high value. We relax our target-flight dates grudgingly, but we must recognize that success is measured in terms of the usefulness of the data received and that abortive flights which provide little or no return waste valuable resources.

The program that we develop, then, is phased in terms of time and resources. The flexibility that we must have in our programing is required by the unknowns that we face as we convert long-range objectives into specific missions and experiments. Each major program is composed of individual projects, and most of these projects are translated into individual flight missions.

In making a decision to hold a flight for further ground test or for equipment modification, we must consider the three factors: data return, cost, and time. As the status of individual projects continues to change, we must make decisions that maximize data return and minimize costs and loss of time.

We have attempted to achieve these objectives in our program through extensive ground tests and checkout. Where warranted, we have provided back-up spacecraft and launch vehicles to help insure data return. In addition, we are conservative in our launch operations. It is our policy not to launch unless there is every reasonable assurance that the mission will be successful. Flights have been scrubbed and schedules changed to allow reexamination of systems, replacement of suspected parts, and even redesign.

One measure of the effectiveness of this conservative launch policy is measured by the record of successful launched, as shown in figure 2. In 1958 through 1960 the NASA record of flight successes to total flights was about 50 percent. Since 1960 the successes have increased steadily. In 1963 the successes were 85 percent.

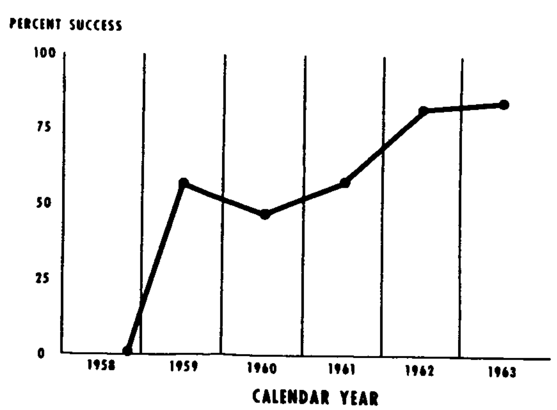

FIGURE 2.—Space flight record.

NASA is the integrating force that carries the final responsibility for mission selection and approach, launch and flight operations, and data collection. However, the growing success of our space-flight program results from the efforts made by Government, university, and industry people. We recognize that these groups of scientists, engineers, technicians, and managers represent our national collective knowledge and capability in aerospace science and technology. These teams have the capability of furthering our understanding of space and advancing our space technology, and of applying these efforts to the general welfare and security of the Nation. Because these groups are important to our future well-being, we are most interested in maintaining a well-directed, balanced program that makes most effective use of these resources.

UNIVERSITY AND INDUSTRY PARTICIPATION

The agency has experienced rapid growth as an organization and has had a commensurate increase in its responsibilities. This growth is perhaps best reflected in the resources NASA has commanded (fig. 3). Our first full year of operation, fiscal year 1959, was at a program level of $335 million and a staffing level of 9,286 people. In this fiscal year we have a program of over $5 billion and a staff of nearly 33,000. The maturing of our organization and its program is reflected in the proposed fiscal year 1965 levels of $5.3 billion and 33,800 positions.

The strength of NASA lies in its field centers (fig. 4). It is here that the work is carried out, either inhouse or by contract. Our centers are widely spread around the country and fall into two basic categories. There are the former NACA laboratories, oriented toward research and advanced technical development. There are the newer space-flight centers, which have grown up since 1958 with a flight project orientation. It is these latter that are responsible for the major contracting efforts of the agency. This distinction is becoming less pronounced as the research centers take on major projects such as the Centaur and Scout launch vehicles, a biological satellite, and a high-speed reentry probe.

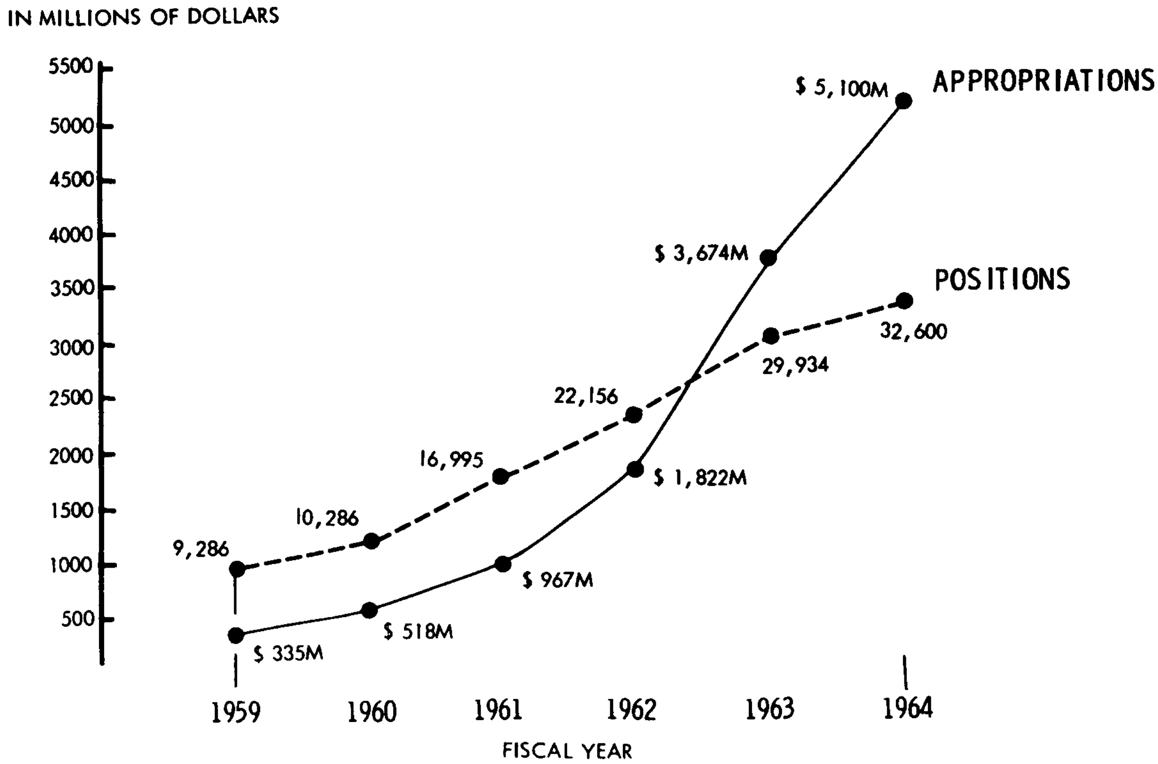

FIGURE 3.—NASA resources.

As our workload has changed and grown, so has our contractor activity (table I). Before 1958, most effort was inhouse and purchasing was limited to parts and components and to facilities construction. In the early NASA years, we began to turn to established contractors who had been carrying out the Department of Defense projects. Today, we deal with the full spectrum: Universities that do research, that provide flight experiments and that train engineers and scientists; nonprofit organizations that provide technical direction to industrial teams; and major primes with responsibility for entire long-term projects. And each of these is but the first tier in the long chain of subcontractors, vendors, and suppliers.

TABLE I.—*NASA Procurement by Type of Contractor*

Type of contractor	Millions per fiscal year			
	1960	1961	1962	1963
Private industry	$174.0	$423.3	$1,030.1	$2,261.7
Educational institutions and nonprofit organizations	17.0	24.5	50.2	102.2
Jet Propulsion Laboratory	38.3	86.0	148.5	230.2
Other Government agencies	107.4	221.7	321.8	636.4
Total contracts	$336.7	$755.5	$1,550.6	$3,230.5
Approximate percentage of NASA budget	65+	80+	90	90

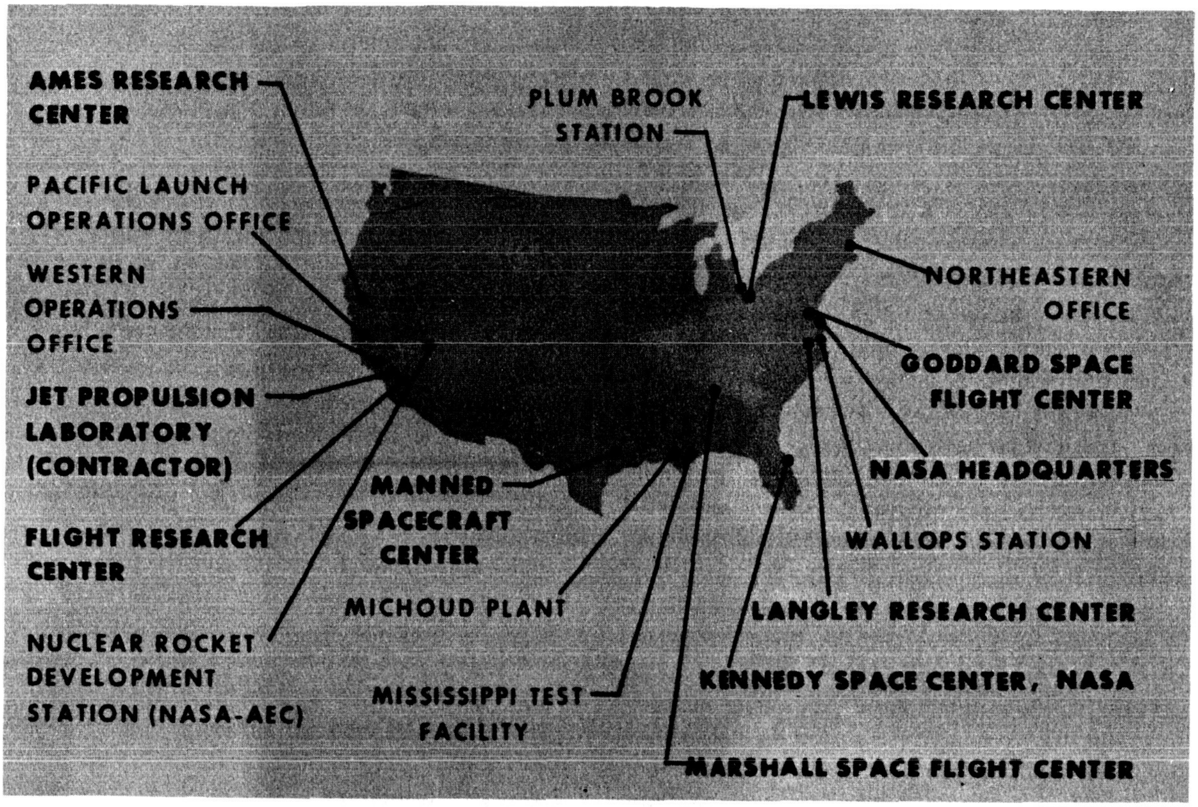

FIGURE 4.—NASA installations.

Almost 93 percent of NASA's work is performed under contract with industry. As indicated in Table II, 70 percent of the total procurements are placed directly by NASA, 5.4 percent through the Jet Propulsion Laboratory, and 17.5 through other Government agencies.

Some 2,500 prime contractors, located in 49 States and the District of Columbia, are engaged in NASA work. Something over $4 billion will be paid to industry for its work under NASA contracts this year.

Less impressive from a dollar-and-cents viewpoint, but of basic importance to our program, is the research into the space environment—its measurement, observation, and use—that is being conducted in more than 100 university laboratories throughout the Nation. More than 4,000 experimenters are participating in this work, in cooperation with at least 20 Government agencies.

CONTRACTING PROCEDURES

In view of all this, it is clear that NASA's contracting policies, practices, and administration are a key part of our overall management process.

TABLE II.—*Industry's Role in NASA Program for Fiscal Year 1963*

How contracts are placed	Millions	Portion of total procurements, %
Directly by NASA	$2,261.7	70.0
Through JPL	174.8	5.4
Through other Government agencies.*	565.2	17.5
Total	3,001.7	92.9

*Army 55%, USAF 36%, Navy 4%, others 5%.

We have had to learn—sometimes the hard way—about the many ways that the form of an original contract will affect the quality of a contractor's management and the end product that he contributed to the program.

Much of our initial work, in particular, was exploratory or "first-of-a-kind," and as a result NASA has often been faced with a serious problem in its endeavors to develop firm specifications and to estimate costs in situations of substantial technological uncertainty. For these reasons, many of our early research and development contracts were on a cost-plus-fixed-fee (CPFF) basis. This appeared to be the best way to give NASA project management the flexibility needed to respond to changes in technological requirements.

It was recognized, even at the time, that the management of such contracts could be influenced to only a relatively limited extent by governmental administrative controls. This is not meant to imply, of course, either a blanket condemnation of CPFF contracts or a dismissal of the importance of administrative controls. On the contrary, they offered us in many cases what was probably the only way to proceed with our early projects.

What we need to do, in the future, is to devise original types of research and development contracts whose form and provisions can strongly motivate industrial management toward improving methods, and ultimately, products. It is for this reason that we in NASA have devoted so much of our attention to ways of improving our contracting processes and contract forms.

Because of varying practices in effect at a number of the NASA centers, nonuniformities in administration of contracts has sometimes been a problem. So many different elements were drawn together to make up the new agency that this development was more or less to be expected. However, we are taking steps to achieve uniform methods as rapidly as possible. There are still a number of important areas that are in need of attention, and we are collaborating with the Department of Defense in this regard.

Finally, improper use of letter contracts has sometimes been a serious source of potential trouble. These lessen the Government's bargaining power at the negotiating table. They often slow down the definitizing process, and in extreme cases can lead to situations which approach the illegal cost-plus-percentage-of-cost relationship. We have found the letter contract to be a generally unsatisfactory way of doing business, even if a cost-plus-incentive contract is finally reached. As a matter of policy, we are striving to eliminate letter contracts except in some very special cases where a specific exception is made in NASA headquarters.

It is almost always easier to pinpoint the shortcomings of contracting procedures than it is to come up with new and better ways of achieving the objective. We believe, however, that we have made considerable progress in doing both. Without ruling out CPFF contracts entirely, we recognize the chief difficulty is that the profit is to all intents and purposes built in at the beginning of a project, on the basis of estimated costs at the time; it, therefore, does not relate nearly so much as it should to the manner in which the contractor actually performs.

Along with this deficiency come other problems—different but closely related. There is no real financial penalty to the contractor who performs poorly, or overruns his costs, or misuses his manpower by pulling people off the job to help write proposals being submitted in efforts to get other contracts. Yet another important deficiency of CPFF contracts is that there is no workable financial deterrent or penalty that can be taken against a contractor that underbids the job to make sure that he gets it and then escalates the cost once the contract is firmly in hand.

There is no reward for efficiency, and no penalty for its absence, even in those overhead and administrative areas which do not relate directly to the technical effort. There can be little accomplished by governmental monitoring of such items because efficiency stems from correctly making literally thousands of small, day-to-day decisions by contractor personnel. A Government followup would simply add that much more to the costs.

To put things into the vernacular of the "carrot and the stick," we are primarily interested in a bigger and better carrot, but we recognize that we cannot afford to throw away the stick. During the past year, we have experimented with a variety of incentive forms of contracts. At the same time, we took steps to begin converting some of our existing CPFF contracts into some form of incentive contracts.

INCENTIVE CONTRACTS

We are searching for a type of contract that will motivate the contractor to become more deeply involved in performing work of high quality with maximum speed and minimum cost.

In this way we hope to reduce the number of persons presently required to carry out what are essentially policing actions. These would be largely unnecessary if we could place more of the responsibility for basic decisions of performance, time, and cost in the hands of industry management. Only through such an approach can we hope to reverse the constant escalation of costs that stems from adding persons on both sides of the equation. This is, as the Government adds people, the contractor has to add people to respond to our people, and the result is not satisfactory to either side.

Going into incentive contracting is not, of course, an easy matter. It is hard to properly establish the incentives in the manner in which they relate to cost and schedule, and particularly to performance—how do you measure performance? But these are the things we are working on and think we are making good progress. We do have some of these contracts working for us now. Table III shows our increased emphasis on incentive contracts, from none at all in 1961 to some 30 as of April 1964.

TABLE III.—*Emphasis on Incentive Contracts*

Fiscal year	Number of contracts	Value in millions
1961	None	
1962	1	$ 7
1963	7	162
To February 1964*	23	313

*At this date 18 additional contracts of over $5 million each were also under negotiation with selected contractors.

Again it should be emphasized that there are three factors we want the contractor to be involved in—cost, time, and performance (fig. 5). We want contracts to be written in such a way that industry management will carefully weigh and consider what any change in his operation will do to all three items. Obviously, there cannot be an alteration in any one of them without a concomitant effect on the other two. We believe that only in this way can the present performance be improved at the contractor level.

The incentive principle holds that a contractor's profit should be related to his ability to: turn out a product that meets significantly advanced performance goals, improve on the contract schedule, substantially reduce the cost of the work, or complete the project under a weighted combination of some or all of these objectives. The principle is not a new one, but the emphasis that it is receiving is new, and it is the core of a major evolution in NASA's procurement policy and practice.

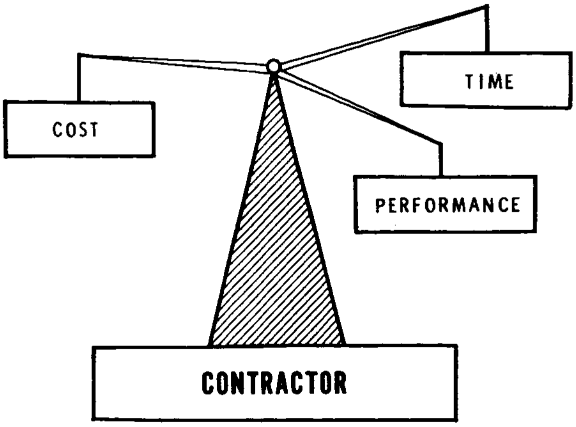

FIGURE 5.—Incentive contracting.

Probably the most important advantage of the incentive contract is that, since profit depends on how well the contractor performs, there is an extremely strong motivation for the contractor to do his utmost. There is a further benefit in that the incentive arrangement forces both parties to consider performance versus schedule versus cost throughout the program.

The gains that we achieve through incentive contracting are not achieved without additional effort, and certainly not without incurring certain risks. If the incentive contract places too much emphasis on reducing costs, the contractor may be tempted to cut costs at the expense of timely delivery or product quality.

We believe, however, that this can be prevented by weighting the various features of bonus and penalty to channel the contractor's efforts to meet all objectives.

In this regard, it might be mentioned that we are exploring the possibility of incorporating much sharper cost reduction incentives in those administrative and overhead areas that do not affect the technical effort. The objective, briefly and simply, is to tailor incentives to each particular case, programmatically and functionally.

This is also a good discipline from the standpoint of NASA's internal operation. These remarks are certainly not intended to imply that the need for improvement applies to industry only; we are fully as concerned with improving the manner in which we carry out our business in-house. It is our aim whenever possible, through careful planning, to define our contracts more clearly and accurately before they are let.

It is clear that the Government's goal must be to procure the maximum effective effort at the most reasonable combination of costs and time. At the same time, NASA needs to maintain flexibility in that as many management and procurement alternatives should remain open to us as possible during the life of the project. And we cannot neglect our responsibility of assuring appropriate quality of performance.

In terms of procurement practice, the ideal approach to a wholly new NASA flight project might run along these lines. First, we would contract with a number of companies for an advanced study which would be designed to establish the broad concepts and various approaches to a given mission or groups of missions. Such contractors would be competitively selected on the basis of the quality of the technical teams they would propose to make available for this task. This group of contracts dealing with the proposed new project would normally be fixed price and all funded at the same level.

After the results have been evaluated by NASA, the next step would be a detailed feasibility and preliminary design effort based on the work already done. NASA would have the opportunity here of selecting two or more of the study contractors based on the previous competition or might compete again with the thought of selecting the top teams that are proposed. This phase of the cycle would normally be CPFF but subject to careful direction by the field center project management group. At the time the feasibility studies are undertaken, it would be made clear that the follow-on development effort leading to flight hardware would, if approved, be let to the more effective contractor.

At the appropriate moment in the conduct of the parallel feasibility studies, NASA would select one for continuation while terminating the others. The contractor selected for continuation would then be awarded a CPFF phase I contract. This would not include flight hardware but would cover the detailed design specification, bread-board models, and test schedules required for the final project. During this phase, the detailed project cost estimates and schedule alternatives would be developed.

When the decision is made to continue into the flight hardware stage, an incentive contract would be negotiated on the basis of the total previous effort and the agreed upon designs and testing programs. The incentive phase would normally include the proof test models and the first several flight units required for missions accomplishment.

In the event that follow-on hardware items are required, two alternates are open: (1) a fixed-price continuation with the original contractor or (2) a fixed-price competitive contract based on the detailed drawings and designs prepared under the previous incentive contract.

This outline of the ideal procurement approach is necessarily a difficult one to follow in that it requires the maximum NASA engineering effort prior to actually having a contractor on board and apparently requires more time between initiation and flight than other approaches. On the first point, greater effort spent in the area of specifications and systems conceptual design will pay dividends in the form of lower total project cost and higher reliability and higher probability of mission success. As to the second point, sometimes the longest route really is the shortest way home.

We believe that by establishing discipline in such a way that incentive profits accrue from keeping costs down, meeting or beating schedules, and maintaining high standards of quality and workmanship, we will afford maximum benefit to both industry and Government.

What we are really striving for, in the final analysis, is not some esoteric, far-out goal. We are striving for mission success, while meeting our schedules and staying within cost.

We have been making—and will continue to make—every effort to ensure that working for NASA will be attractive to industry, providing, of course, that the work is well done. We want success to be extremely attractive. Conversely, we intend to make failure, sloppy work, or wastefulness of the taxpayers' dollars extremely *un*attractive.

We believe that a contract should be designed to encourage industry to be as proficient as possible, rather than assume that industry requires constant policing. If top industrial management is motivated to become deeply and personally involved in the work they are performing for NASA, the risks to themselves and to the Government will be minimized. By proper use of this team concept, we believe it will be possible to achieve pre-eminence in space in this decade.

GOALS FOR THIS DECADE

We plan to develop the Saturn I–B and Saturn V launch vehicles capable of placing 34,000 pounds and 220,000 pounds, respectively, in Earth orbit. We will have facilities for manufacturing, testing, and launching these vehicles with the Apollo spacecraft. We will have tracking stations, tracking ships, worldwide communications, and mission control facilities for manned flight in Earth orbit and out to the vicinity of the Moon. We will have a thorough understanding of the space environment about the Earth, between the Earth and the Moon, and we will have investigated the lunar surface and selected possible landing sites. These major program elements are scheduled so that a manned lunar landing and return can be conducted in this decade. Technological progress, environmental conditions in space, and dedication of purpose will determine whether we attain these goals on this target schedule.

These goals cannot be achieved without a proper partner relationship of Government, industry, and universities. It is the acceptance of this challenge by all three participants that will, in the long run, permit success or lead to failure. Our most difficult job is to provide the appropriate framework of incentives and controls that allows and nourishes this all-important joint participation.