

We particularly commend measures already taken to give both military and civilian personnel special training in project management; to form project teams that cut across conventional organizational lines; to use formal management techniques for the better coordination of complex programs; and to increase the technical competence of government project-management teams by encouraging them to draw on the resources of industrial contractors, non-profit companies, and universities.

More than half of all scientists and engineers employed by private industry in research and development are working on projects financed and supervised by the federal government. The effectiveness of their efforts depends in very large degree upon the skill with which the government manages these projects. A single unwise decision in the fixing of design objectives may delay by a year the development of a space vehicle or a weapons system, and add a thousand man-years of scientific and engineering effort to its cost. Conversely, an alert and technically competent project-management team can effect enormous savings in time and effort by skillfully coordinating the activities of contractors working on different but related phases of a major space or weapons system.

It appears that the successful development of two particular weapons systems, for which the Committee had case studies prepared, can be traced in part to skillful management for both the government and industry by strong project offices.

Many large government research and development projects have in fact been handled most competently. But we believe that the quality of management could be substantially improved by wider use of techniques such as those recommended above and by recognition and reward of exceptional work. It would be improved further by the passage of legislation raising the salaries of scientists and engineers in the upper civil service grades, from whose ranks the members of project-management teams are in large part recruited. The military services, also, need to give more attention to the development and retention of this kind of engineer-manager in their officer corps.

5. Government agencies responsible for development programs should continue to place great emphasis on accurate estimates of their cost and feasibility, and on the use of multi-phase contracts.

The Committee is impressed by evidence of the government's growing skill in estimating the cost of projected programs, and in determining their technological feasibility before large amounts of money and manpower have been committed. The government is also to be commended for increased use of multi-phase contracting, a system under which several companies, chosen in competition, are awarded contracts calling for preliminary study and task definition. The company that performs best in this early and relatively inexpensive phase is then awarded a development contract. One of the several advantages of multi-phase contracting is that it tends to reduce the number of prospective contractors submitting major proposals for a development program, thus reducing the investment of scientific and engineering talent in the preparation of proposals.

6. In development programs, the use of fixed-price and incentive contracts instead of cost-plus-fixed-fee contracts is to be commended. Great care must be taken by government agencies to establish meaningful and realistic performance criteria.

In general, the Committee favors the increasing use of fixed-price and incentive contracts for development work. It is clear that the payment of higher fees to contractors whose performance is superior is likely to result in over-all improvement in the efficiency with which scarce technical talent is utilized in government-financed research and development programs. There is a danger, however, in overemphasizing objective performance criteria in contracts, in such a way that a company's profits become related to the achievement of goals irrelevant to the central objective for which its services are secured. For example, early operational capability and low cost are usually desirable characteristics for military systems. But if the need is for a highly dependable back-up to a system already in the field, care must be taken lest a premium paid for speed of contractor performance, or an undue penalty for a cost overrun, divert attention and effort from the primary goal of reliability.

7. The Committee commends federal contracting agencies in the fields of defense and space for their increasing ability to act at an early stage to cancel, curtail or materially alter major programs that do not appear to be worth their cost.

Because of the necessarily speculative nature of development, it may often prove impossible to reach a desired goal by continuing to move along a particular line, or to reach it soon enough at an acceptable cost. Significant reductions in waste