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# A SYSTEMS APPROACH TO THE MANAGEMENT OF LARGE PROJECTS

## REVIEW OF NASA EXPERIENCE WITH SOCIETAL IMPLICATIONS

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# A SYSTEMS APPROACH TO THE MANAGEMENT OF LARGE PROJECTS

*Review of NASA Experience with Societal Implications*

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The reality of men having landed repeatedly on the moon is evidence of the great technological and management accomplishments of the American space program. These feats were achieved in an amazingly short span of time. When President Kennedy announced in 1961 that the United States would land a man on the moon by 1970, it seemed that this goal could hardly be realized by the end of the century, much less the end of the decade. The complexity, the risk, and the unknown factors were of such great proportion that persons in government, education, the press, and other walks of life had serious doubts about the realism of the task. Even as late as 1968, only a year before the lunar landing, the probability of success was discounted by many critics.

Why did NASA have confidence in its ability to go to the moon? Two factors accounted for its optimism: (1) the excellent technical record of the agency; and (2) the power and versatility of its systems management approach. NASA's technological success was witnessed by millions of people all over the world who viewed the lunar landings on television. NASA's use of the systems management approach to achieve its goals focused managerial attention on the applicability of this approach to reach objectives in other fields. This article explores that possibility.

## THE CHALLENGE

NASA had been in existence for only three years when the Apollo project was begun in 1961. The challenge given to the agency was unparalleled in the history of government. National prestige was laid on the line in a most dramatic and awesome manner, with the entire world judging the merits of the technological and managerial prowess of the United States.

The agency of government entrusted with this seemingly impossible task was new. It was a small civilian organization endowed with no sweeping emergency powers, and required by law to operate within strict government regulations binding all regular units of the government. The nation was at peace. Financial support for the lunar landing would have to be obtained in competition with other national priorities.

NASA needed a management approach capable of nurturing technological progress while at the same time being powerful enough to ensure the coordination of many diverse organizations, resources, and skills. The agency realized that there would be many unknown hazards for men and spacecraft in the attempt to reach

the moon. Therefore, the management approach had to have a capability to detect and identify potential problems and hazards in the most minute detail. Concurrently, management in the space program had to be able to move boldly and make choices decisively. Management had to be flexible and responsive to changing circumstances and new developments. To anticipate problems, the management had to be able to monitor all significant activities, test the environment for changing conditions, and obtain feedback.

Finally, because the task was of such huge proportions, it was clear that the nation's industrial and educational capacity would be involved to a large extent. Mastering space would also require an interdisciplinary approach with scientists, engineers, and professionals in scores of specialties working together in newly formed, integrated teams. Management had to have the capability to ensure that many sectors of society and professional disciplines would work smoothly toward the common objective.

NASA MANAGEMENT OUTLOOK – 1961

| STAKES | POLICY | LIMITATIONS |
|---|---|---|
| NATIONAL COMMITMENT | CIVILIAN AGENCY | 1970 DEADLINE |
| INTERNATIONAL PRESTIGE | WIDE USE OF INDUSTRY AND UNIVERSITIES | NO EMERGENCY POWERS |
| TECHNICAL LEADERSHIP | | COMPETITION FOR SUPPORT |

Thus the basic conditions under which NASA had to manage were:

(1) The greatest technological achievement in history was the goal.

(2) The national prestige of the United States was at stake.

(3) The goal had to be achieved within nine years – by all criteria a very short time.

(4) The goal had to be accomplished by a small, civilian agency during peace time; no emergency powers could be used; and funds would have to be obtained from Congress in competition with other needs.

(5) Major segments of industry and educational institutions in the nation would be involved in the effort, along with hundreds of professional specialties.

(6) Coordination and direction of diverse organizations, resources, and skills on a tremendous scale would be required.

(7) Precision, detailed control, and early detection of emerging problems were vital.

(8) Flexibility and a capacity to make bold and decisive choices were needed.

(9) The agency could not afford to fail.

Clearly, a wide array of innovative management methods and techniques would be needed to meet the challenge. Recent experience had demonstrated that the conduct of large scale technological projects is facilitated by the use of the systems management approach. Essential elements of this concept had been used both in large scale commercial and industrial construction projects funded by the private sector as well as R & D technology-based public service support programs funded by the Federal Government.

Basically, systems management requires that those in charge adopt as large a view of the project or problem as is practical. All significant elements must be considered by management, and a plan of action devised for integrating all personnel and resources into a unified effort to realize the objective.

## INFLUENCE OF NASA ENVIRONMENT

The way in which systems management was used in NASA was heavily influenced by the background and traditions of the agency and the special circumstances involved in its evolution. Although NASA was a new agency, it was made up largely of personnel from a number of other federal research and development organizations with the following characteristics:

(1) Proud records of scientific and engineering accomplishments

(2) Highly career oriented

(3) A tradition of close cooperation with industry and universities

(4) A history of utilizing the latest technological innovations for both technical and management problems.

## EMPHASIS OF MANAGEMENT APPROACH

Shaped by these considerations, NASA's adaptation of systems management had the following basic elements:

(1) Emphasis on achieving technical excellence
(2) Top management involvement in planning and implementation
(3) Strong in-house technical competence
(4) Project management
(5) In-depth monitoring of contractors.

## EMPHASIS ON TECHNICAL EXCELLENCE

Success for Apollo and other major space projects depended primarily on technical capability. No matter how much money or other resources were invested, no matter how able the management team, no matter how strong the national will, success would be elusive unless the technical problems were conquered. Going to the moon was primarily a technical task. NASA Management, if it did nothing else, had to ensure that the best technical personnel available were utilized and that they were given the resources, tools, and environment to perform. The top management team, therefore, included technical experts universally recognized as leaders in science and engineering. Sensitivity to the needs of technical personnel was built in by the make-up of the management team, and by giving technical personnel high status and wide decision-making powers in all levels and phases of agency operations.

## TOP MANAGEMENT INVOLVEMENT IN PLANNING AND IMPLEMENTATION

It was clear to NASA leadership that the planning process, dealing with commitments of resources and establishment of policy approaches, was crucial to the success of the lunar landing. Implementation of plans can only be left safely to experts when the process of execution has become more or less routine. This was hardly the case with the initial flights to the moon. Top management involvement in these functions was viewed, therefore, as essential.

## IN-HOUSE TECHNICAL COMPETENCE

NASA realized that to most effectively utilize the technical capabilities of the industrial and university community, it was necessary to maintain a strong in-house technical competence. This basic decision, reinforced by experience from the pre-NASA agencies, was made more relevant because 90 per cent of all NASA effort was to be contracted out to industry and universities. (See Figure 1.)

## PROJECT ORGANIZATION AND MANAGEMENT

In its implementation of the systems management concept, NASA utilized the Project as the central element in its organizational structure. Project organization and management are uniquely designed to harness the enterprise of all facets of the agency which can contribute to goal achievement. Yet, the project is established only to meet a single goal. When the goal is realized, it is disbanded. It can expand to nearly any size and then shrink to zero. Meanwhile, the host organization continues to conduct business in the usual manner: its essential functions continue undisturbed by the stresses and turmoil of the demands of a given project and remain ready to deal with the continuing challenges of the agency.

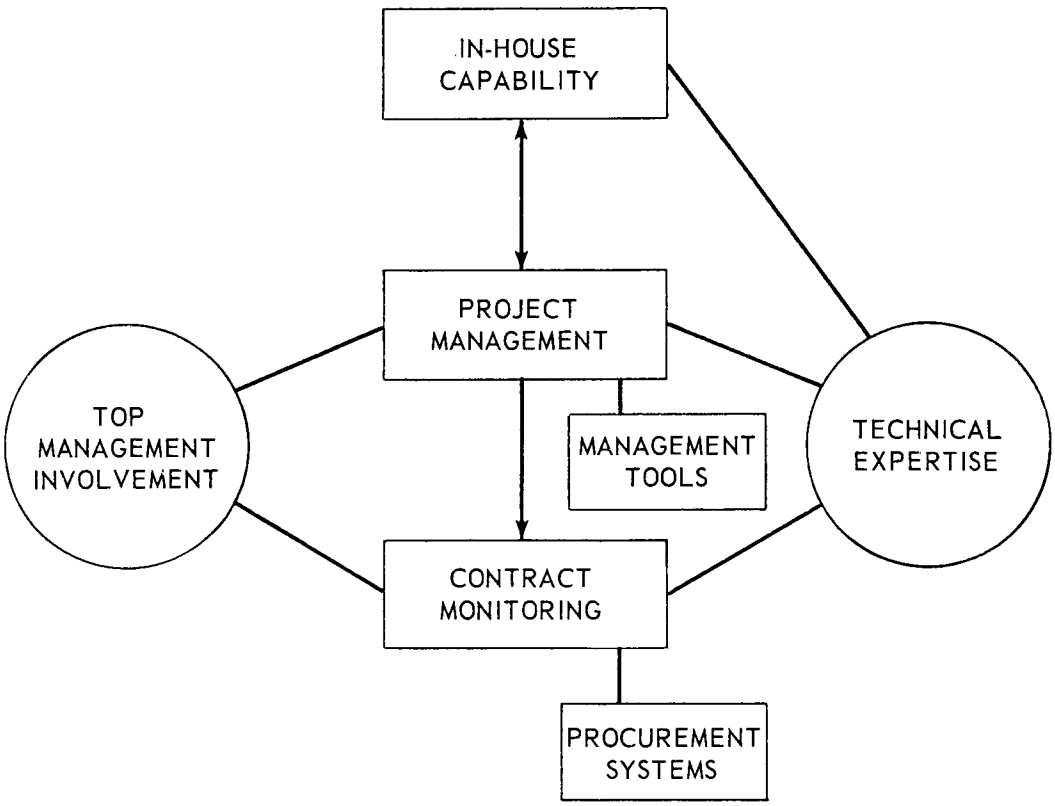


Figure 1. Systems Management in NASA

The project manager in NASA is responsible for all activities in the project, and must meet established objectives within given time and cost limits. Project managers take responsibility for organization, planning, decision-making, and follow-up. To achieve results, the project manager must utilize his technical leadership and management skills. He must possess the ability to motivate the project staff and to integrate the effort of project staff specialists with "outside" specialists.

## IN-DEPTH MONITORING OF CONTRACTORS

The high risk factor of space exploration and the emphasis on success prompted NASA to insist that contractor performance be superior in all respects.

In-depth monitoring by NASA of all significant phases of contractor activity was the solution. Not only were problems averted by this knowledgeable penetration, but superior performance within time and cost limits was more frequently achieved.

## APPLICATIONS TO SOCIO-ECONOMIC PROJECTS

Although the use of systems management was successful in meeting the challenges of the space program, there is a basic question as to its application to socio-economic projects, such as transportation, housing, and social services. The differences between technological and socio-economic projects are at the heart of this question. In socio-economic matters, the objectives are usually less well-defined than is the case for technological activities, the methodology is less well-developed, and the variables involved (interest groups, community preferences, etc.) are much more difficult to control. Yet, systems management has the capacity, as evidenced by the space program experience, to deal with complex problems with high degrees of uncertainty and numerous unexpected developments.

These considerations indicate that systems management is more applicable to technological enterprises than to socio-economic programs. Nevertheless, there is sufficient experience to demonstrate that systems management is useful also to socio-economic enterprises. Figure 2 represents schematically the potential for useful application of the systems approach to such ventures.

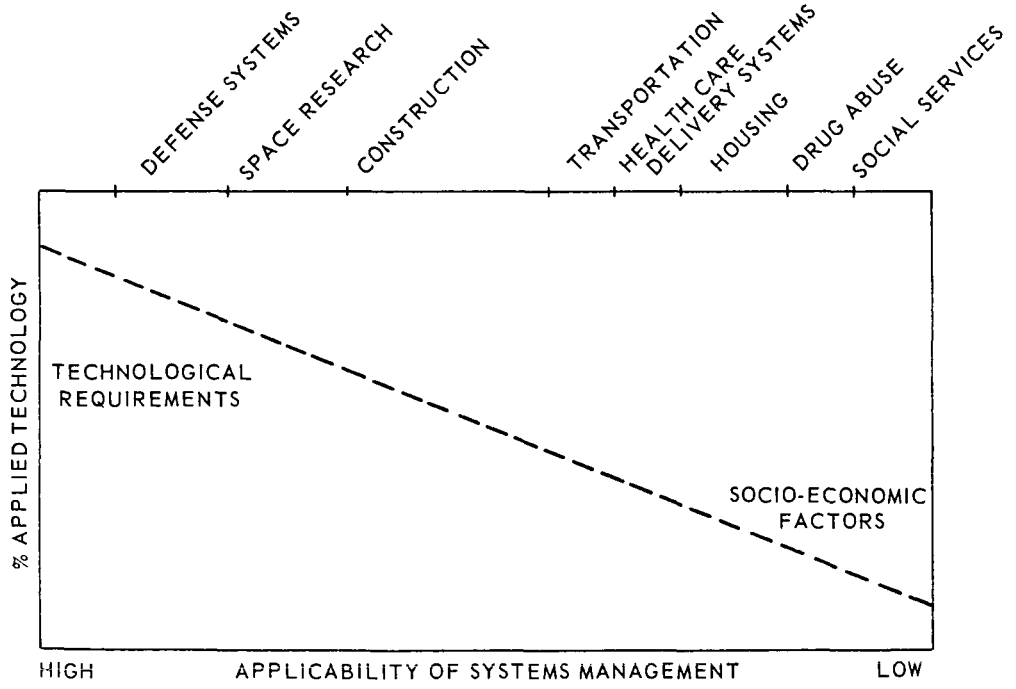


Figure 2. Systems Approach Utility Scale

In the examples that follow, the concepts of the systems management approach will be examined in connection with their application to certain socio-economic projects.

*Development of a New Community*

Systems management was utilized to plan and develop a new city in the United States (projected population approximately 100,000). Experts in city planning and urban living have called it an ideal place to live and work. Both employment and recreation are easily accessible to residents by foot or excellent public transportation, thus reducing much of the friction and wear and tear of modern urban life. Many other advantages are present.

The conditions under which this city was begun parallel those in the Apollo project. There was a public declaration of intent, a firm timetable, and a clear goal (including the need for a return on investment). Extensive contracting was necessary. Major differences from a space project were also present, however: The multi-thousand acre site had to be purchased from numerous small owners; the interests of environmentalists had to be accommodated; building and zoning codes plus marketing requirements had to be satisfied; and a school system meeting all state educational standards had to be created.

The systems approach used by company executives included project organization and management, and the use of a computer-based development model which was constantly modified and updated when feedback indicated that changes were vital to keep the project viable and profitable.

*Operation Breakthrough*

Systems management also plays an important role in bringing industrialized housing to the United States. The U. S. Department of Housing and Urban Development (HUD) is conducting an experimental project called "Operation Breakthrough." The goal is to provide factory-built housing at reasonable prices on a rapid basis to help alleviate the shortage of low and middle income housing. A systems approach was chosen because of the complexity of the project which involved proposals for changes in building codes and in zoning laws in all 50 states. Industrialized housing, both single home and large apartment units, is now being assembled at nine locations throughout the U. S.

*The Metroliner*

In an effort to accelerate the development of high-speed rail transportation, the U. S. Department of Transportation, working closely with railroads and several large industrial firms, has developed a pilot-program, high-speed rail link between

New York City and Washington, D. C. Because of the novel problems involved, including development of new "space age" locomotives and cars, systems management was utilized. The Metroliner is now well established as a model for fast, comfortable, and efficient rail transportation.

### *Housing and Social Services in County Government*

Providing better local government services through the use of a systems management approach was the objective of a project undertaken from 1970 to 1972 in a county government located near Philadelphia. This attempt is of particular interest because technological tasks were not involved. Rather, the problems were social, involving housing and community services. It was necessary to obtain the active support of citizens and civic groups to ensure successful completion of the tasks. Further, prior to application of systems management, all progress in delivering the housing and community services involved had been unsuccessful.

A simplified form of systems analysis was used to identify the causes for earlier failures in achieving progress in delivery of housing and community services. Reports of these efforts indicate that utilization of the systems management approach contributed substantially to project planning and implementation.

### *Other Applications*

The use of the systems management approach to socio-economic projects is growing. New York City is making extensive use of project management. Dayton, Ohio, utilizes "task forces" to attack basic urban problems. The University of Alberta, Canada, has a new $100 million medical complex planned and designed in conjunction with TRW, Inc., using systems management.

The range of applications is important evidence of the utility of systems management for large scale or complex ventures with substantial socio-economic influences.

## IMPLICATIONS FOR FUTURE PLANNING

There is considerable evidence that the systems management approach as applied by NASA can be useful in the planning and implementation of large-scale complex projects aimed at resolving some of our socio-economic problems. Complex space flight projects and large socio-economic projects have many common elements: both exist in a dynamic environment; new knowledge and technology is required for problem solving; enormous resources need to be committed and controlled; and a complex interplay of interdisciplinary skills and institutions is involved.

It has also been demonstrated that there are significant differences that characterize space flight and socio-economic projects. Large space flight projects are

amenable to final and interim goal setting, but acceptable interim goals are more difficult for the participants in the solution of socio-economic problems to define.

Space flight projects functioning in essentially monolithic organizations have, with reasonable success, been able to select project managers, team members, and the specific managerial support systems to be used in project implementation. Many socio-economic problems do not have this advantage, for they exist in an environment wherein some of the participants and managerial support systems are selected by a political process which, at that point in time, may be only tangentially related to the specific needs of the project.

These are some of the implications of applying the systems management approach to socio-economic problems. They are not insurmountable but do require adjustment and innovation in their application. Even if the approach, *in toto,* is not applicable in a given situation, many of the supportive management systems will find application. When approached with realism and applied with flexibility the systems management approach can be another "giant step" for the benefit of all mankind.

## A FINAL NOTE

This article has been prepared as an analytical review of the NASA experience for the general reader with a background in management, sociology, and economics. In-depth expositions of the theory and applications of system management are available in the open literature. Exhaustive analyses of the NASA experience, in many cases funded by NASA, have been conducted by teams representing universities and nonprofit organizations. For the general reader who would like to pursue the subject in more depth, a brief, annotated bibliography of generally available reference sources is listed below:

(1) J. Gordon Milleken and Edward J. Morrison,

"Management Methods from Aerospace," Harvard Business Review, March/April, 1973.

*A businessman's guide to 25 specific techniques and concepts that offer commercial sector potentialities.*

(2) James Webb,

Space Age Management (New York: McGraw-Hill 1968)

*The challenges to NASA management and its responses are cogently presented by NASA's chief executive from 1961 to 1968.*

(3) Leonard Sayles and Margaret K. Chandler,

Managing Large Systems (New York: Harper and Row, 1971)

*An in-depth analysis of how NASA and other organizations manage large projects. Includes discussion of the applicability of systems management to business and social problems.*

(4) Frederick I. Ordway III, Carsbie C. Adams, and Mitchell R. Sharpe,

Dividends from Space (Thomas Y. Crowell Co., N.Y., N.Y., 1971)

*A catalogue of the benefits of space technology for problems on earth, including application to communications, medicine, weather prediction, mining, and agriculture.*

(5) David Wilemon,

"Transferring Space Age Management Technology," The Conference Board Record, Vol. VII (October, 1970)

*An incisive review of the potential and difficulties of transferring modern management techniques to industry and government.*

(6) David I. Cleland and William R. King,

Systems Analysis and Project Management, (New York: McGraw-Hill, 1968)

*A valuable book describing and analyzing modern management techniques and their applications.*

For the European reader, the activities of INTERNET, the International Management Systems Organization, will be of considerable interest, especially the published Proceedings of the Third International Congress on Project Planning. Information on INTERNET and details about the availability of copies of the Proceedings may be obtained from:

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