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PROGRAM CONTROL IN NASA: NEEDS AND OPPORTUNITIES

by a Study Team of the National Academy of Public Administration
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The National Aeronautical and Space Administration (NASA) has successfully managed some of this country's most complex technology and development programs. These successes have included the application of sound program control processes. The impetus for this study arose from the NASA Management Study Group findings that over time, some program control tools and disciplined procedures and processes had weakened. The Study Group recommended that steps be taken to establish a comprehensive training approach in program management, and specifically, in program control functions. This study looks at program control processes within NASA currently in use, defines a "model" of program control functions, and provides recommendations on program control training needs and opportunities.

In 1988, NASA Headquarters tasked the National Academy of Public Administration (NAPA) to examine the processes and systems used by NASA to manage and control program and project activities. Essential elements of a program control system include program development planning and documenting program requirements; integrated scheduling; resources management; configuration management; documentation and data management; establishment of essential baselines; and the conduct of performance reviews. Specifically the NAPA study was designed to include:

- Determination and definition of program control functions as currently practiced in NASA.
- Definition of a model of program control functions for NASA.
- Observations on training of personnel.
- Generation of recommendations for training in program control objectives and processes at the basic, intermediate and advanced levels of project management.

The impetus for a program control aspect of program and project management training and developmental efforts can be traced to a series of findings and recommendations on strengthening program management and control functions which were derived from the Rogers Commission and the NASA Management Study Group (the Phillips Committee) reports. In reviewing the total function of NASA program management, the Phillips Committee found the weakest area to be that of program planning and control. Committee members commented that over time NASA's use of program control tools and disciplined procedures and processes had weakened. They recommended the reinstitution of a Program Approval Document system and a revitalized hierarchy of program/project status reviews against approved baselines. In addition, the Study Group recommended that steps be taken to develop a comprehensive training approach in program management, specifically in program control functions, that would be based on real experience.

The significance of the program control functions within NASA cannot be overstated. The success of large and complex research and development projects depends on commitment, diligent and disciplined attention to numerous planning, resource and scheduling variables, and the integration and balancing of complex, interrelated activities. Along with the systems engineering function, the program control function is one of the most important activities in successful program/project management. Systematic and disciplined attention to the implications of variances between planned baselines and actual performance on development projects is critical to taking early remedial action, reducing costly delays and achieving success.

The purpose of this study is to indicate the areas of need as well as provide guidance to the development of training opportunities concerned with program control in support of effective program/project management in NASA. The study could not have been completed without the assistance of NASA employees at field Centers and Headquarters. Their contributions helped the staff to understand the application of project control functions at different Centers. Special thanks are owed to Frank Hoban, Program Manager, NASA Program and Project Management Initiative, who provided the Academy with the environment to pursue the study.

The Program Control Function

In NASA, a project ". . . is a defined, time-limited activity with clearly established objectives and boundary conditions executed to gain knowledge, create a capability, or provide a service." Major space research and development projects in NASA typically include design, development, fabrication, test, and flight operations. A program/project manager is designated responsible for ensuring the performance of all functions necessary for management of the project. The three basic elements of the manager's job are technical performance, cost and schedule. The program/project manager needs to know where the project is at any point in time and to identify and scope problems early. Program/project control, which aids the project manager in this regard, is the total management process of establishing and maintaining program baselines and effectively supporting the project manager in meeting the overall objectives of the project.

The combination of functions of program control is an essential element of the program management process. The establishment of comprehensive performance requirements by systems engineering provides the details and parameters necessary for program control to maintain a comprehensive, adequately explicit and integrated program plan. This plan documents and defines program requirements and establishes the official baselines of program content, scope, configuration, schedule and cost. A comprehensive program control process includes procedures for reporting and reviewing performance against baselines; analyzing and synthesizing program performance; evaluating alternatives; developing disciplined processes for considering, approving, and implementing changes to official baselines; and assuring positive feedback on all directions and decisions. It also provides a uniform system of program documentation and assures clear and consistent communications throughout the program community on program progress, status, and issues. The integrated operation of these functions furnishes the means to determine the harmony of actual and planned cost, schedule, and performance goals during development and fabrication by verifying whether everything is occurring in accord with baseline plans. The larger point is clear: a program control system requires sustained attention to the system as a totality, rather than as a group of parts.

Ultimate responsibility for the effectiveness of program management control rests with top management. Top management decides upon Agency strategy, policy, and organizational and accountability structure. The control system is a set of major tools and procedures for implementing those decisions and for forming coherent and defensible strategies to cope with changed and changing circumstances. For the most effective program management and control to exist, an *environment* of accountability of organizations and individuals needs to exist at the top of the Agency. It should be clear to the entire Agency how NASA intends to operate and what is expected of all elements. Delegations of authority, definitions of roles and assignments of responsibilities should carry with them the terms of accountability. Disciplined processes for obtaining required feedback on delegations and for measuring and systematically reviewing performance on programs and projects should exist. The pattern of program reviews against approved program baselines should also be established at the top. This can consist of separate reviews or be a part of the general management review process, but a disciplined approach of reviewing status against approved baselines by the Administrator and/or the Deputy is needed. The strength of such an approach is that it allows Agency leaders to directly, programmatically and effectively keep tabs on the performance and potential pitfalls of programs. This in turn enables top managers to identify and consider the implications of both "inside" factors and "outside" factors, forces and trends which are likely to have an effect on NASA and its missions.

A number of characteristics distinguish NASA research and development projects, including:

- *Uncertainty.* Many of the processes and products to be developed will be undertaken for the first time and all components require the performance of advanced technologies.

- *Long lead times in development and fabrication.* This necessitates concurrent development of elements and subsystems and the fitting of end products together. It requires a high order of advance planning and detailed monitoring and tracking and increases the need for testing (component testing, subsystem testing and system testing).

- *Size and complexity of projects and the large number and dispersion of participants.*

- *Persistent scrutiny of projects by the public, the Congress and the scientific community.* Not only must the work be done well, the project manager must be prepared to interpret, explain and defend what is being done and why. Practices and standards for public projects far exceed typical industry standards.

Against this background, it is important to keep in mind that good program management is a matter of balancing different internal and external factors so that performance is maximized over the longer term. Program control interventions, if used correctly, help to maintain this balance.

Major Functions of Program/Project Control

The basic control functions for development projects are planning, configuration management, scheduling, resource management and data management. In some cases procurement activities and other business management activities may become part of the control function, as well as logistics and separate activities for program analysis, management information and program reviews. The combination of activities included depends upon the size and complexity of the program or project, the existing support structure and the preferences of the Centers and the individual managers. Regardless of the individual functions, more than anything else in program control, it is important for the personnel to see and comprehend the totality of the job to be done and to thoroughly understand the interrelationships and interfaces of the subsystems and systems, as well as the organizations and participants in the project. Another important element in structuring and carrying out program control functions is uncertainty and the inability to completely eliminate it. Uncertainty should be specifically considered in program planning, scheduling and resource planning.

Program Plans and Requirements

The development plan is the basic plan for execution of the program or project. It is the top-level requirements document and the top-level implementation plan. It is the single authoritative summary document that sets forth the manner in which the objectives shall be accomplished. It defines the program organization, responsibilities, requirements, resources and time phasing of the major actions required.

Program planning sets forth the development requirements needed to establish and maintain an integrated planning baseline of what is to be done, how it is to be done and when it is to be done. It is not a one-time process, since the development of detailed performance requirements are not established at one point in time. In addition to the technical requirements, detailed management and mission requirements should be established. It is a continuing process of laying out and ensuring a unified effort in implementing the program, adjusting to changing conditions, maintaining the program or project development plan, and integrating ongoing technical requirements. Although planning steps are laid out in a linear sequential manner, the process is iterative.

The technical requirements establish the work packages. The development of the project work breakdown structure (WBS), consistent with the Agency coding structure, may also occur in conjunction with the planning function or it may be part of one of the other functions. On NASA development projects the WBS will normally be end-item oriented rather than discipline oriented.

Resources Management

Resources management includes the establishment, monitoring, and maintenance of obligation and cost as well as the manpower baselines. Manpower constitutes the vast majority of development costs, and knowledge of status and trends are extremely important. The reporting structure for cost should be established and maintained with an emphasis on cost phasing and cost to completion. Reporting systems and selection of report items should be designed to raise questions, not to answer them; the implications are important, not the absolute value recorded. The absolute value is useful only for historical and legal purposes.

The planning of reportable items is usually achieved through use of the Work Breakdown Structure accounts. The structure and analysis of report implications should be correlated closely with schedule and technical performance. The recording and reporting of cost alone has little or no value as related to performance implications in the future; one of the main purposes of resource and schedule analysis is to recognize implications and to reduce management surprises. This allows for identification and evaluation of "what ifs" and alternatives. The initial and subsequent cost estimates must recognize and quantify risks and uncertainties and provide reserves and allowances for program changes. The requirement for uncertainties and risk is as vital to project success as any other cost element. Having contingency funds available and using them judicially are integral parts of successful research and development efforts.

If the contractor reporting structure attempts to closely parallel schedule and cost reporting milestones, extreme care should be taken that it is not based on the assumption of equal value milestone performance. This type of system can easily lead to some misleading assessments. If such a system is used, program changes can completely disrupt performance reporting and require installation of a new structure of report accounts and a long hiatus in reporting. To base a system on an assumption of continued program equilibrium would be a mistake—uncertainty is much more likely to be the norm.

Configuration Management

The purpose of configuration management is to provide a disciplined systems approach for the control of the requirements and configuration (normally established by systems engineering) of hardware and software to be developed and the process for change consideration.The function basically consists of four distinct practices:

- *Configuration Identification*—The definition and establishment of the total technical requirements (performance and functional) and the detailed configuration definition and documentation. Configuration identification is usually established incrementally as design and development proceed.

- *Configuration Control*—The formal process used to establish and control changes to the configuration baseline. This control is effected through a hierarchy of formal configuration control boards established at the different levels of hardware and software.

- *Configuration Accounting*—Performance of this function "defines" the exact baseline on a continuing basis and provides a clear audit trail from the authorization of changes into the affected documentation. It should provide the single authoritative source for baseline definition.

- *Configuration Verification*—Ensures that the baseline configuration requirements have been incorporated into contracts and are fabricated and tested accordingly.

Documentation Management

Documentation management establishes data policies and responsibilities and procedures for identifying, planning, selecting and scheduling a large volume of data. The data management system ensures continual management review of NASA-generated and contractually required documents, eliminates any non-essential requirements, and assures only the minimum amount of documentation necessary for effective program management. The principal intention of the system should be to define the information required, justify its need, and control the information after it is generated.

Schedule Management

This function provides for the development and maintenance of the master schedule and the detailed, interrelated schedules covering the total program or project to completion. It involves the requirement to define the schedule format, content and symbols used.. A critical component of the function is selecting the key progress indices for measuring performance and indicating potential problems. A system of reports, reviews, and action feedback needs to be provided. Working closely with resources management, the analysts must evaluate performance, synthesize various inputs and implications, and generate and evaluate alternatives. Plans and schedules should provide for uncertainty and the unknown.

The integrity, reliability and discipline of the reporting system are essential. NASA should continually assure the end-to-end integrity of program control data from its source in subcontractors to prime contractors and subsequent levels of NASA. The importance of early problem recognition cannot be overemphasized: the ideal control system detects potential deviations before they become actual ones. The costliest aspect of a development program is time. Slippages in a program schedule are extremely expensive. A permanent record of all changes and slippages should be kept to allow trend analyses.

The primary steps of management accountability—establishing objectives and baselines, measuring performance against baselines, analyzing and evaluating performance and alternatives, assigning action or direction, and ensuring action feedback—are applicable to the management of almost any activity. Some aspects of control functions such as planning, scheduling activities, and managing resources are also applicable in some degree on all NASA work, including applied research and technology, science tasks, and institutional management. However, the collection and staffing of the full array of project control functions are not necessarily appropriate for all activities within NASA. The style of management and types of controls require tailoring to the particular objectives and problems of the individual activities.

How program control functions are grouped organizationally is a consequence of a number of factors. Nevertheless, it is clear that all of the functions and their outputs need to be integrated. On a small project, a project manager could possibly perform the functions and integrate the data output. On relatively large or complex development projects or programs it is the opinion of the Academy team that management control and synthesis of program element progress and performance are enhanced by grouping the functions. A model that lays out program control functions suitable for most large and complex development projects is shown in Figure 1. This model assumes that program analysis is an inherent part of the functions shown. As a matter of preference, however, program analysis can be handled as a self-contained function.

Current Status of Program Control in NASA

As a part of this study, the Academy made an effort to ascertain the current status and health of program/project control functions and processes within NASA. Interviews and discussions were held in both Headquarters and Centers with Center Directors, directors of flight projects, program managers and personnel who play roles in program control functions. Discussions were also held with previous NASA program directors, some aerospace industry officials and support contractors supplying management services to NASA.

In Headquarters, the reinstitution of the Program Approval Document (PAD) System has not moved swiftly. Dale Myers, Deputy Administrator in 1987, sent a letter with instructions for preparation of PADs in June 1987. On March 14, 1989, a management instruction (NMI 71211) was issued, which required the specific development of 23 separate PADs with provisions for adding or deleting projects in the future. Approximately eight have been prepared and approved. The Deputy Administrator is holding meetings with program offices in an attempt to tailor the format, content and level of detail of the document, and to define the management processes to fit the desired methods of operation in an orderly and efficient fashion.

Since early in its history, NASA documented its management policy and principles of project management as well as instructions on planning and approving major research and development projects. These instructions were canceled in the mid-1980s when the PAD system was eliminated. Efforts have apparently been made to reinitiate or replace some of the canceled documents, but at this point, it has not been accomplished. An understanding of how the Agency intends to operate and what is expected in terms of project management approaches and techniques does not currently exist within the Agency. A common concern among senior managers at the Centers was the apparent lack of appreciation of the usefulness of such policy statements on the Agency's operation.

General management status reviews continue to be held at Headquarters. The current review system provides for three separate meetings—one for Space Transportation and Space Station, another for all other programs and projects, and a third for institutional activities. According to some attendees, these reviews could not be characterized as disciplined reviews of progress against established baseline milestones and goals. However, program offices participating in these reviews do characterize the status and problems of projects.

The organization and performance of program/project control functions within the program offices and the development Centers have not materially changed or improved since the Management Study Group findings in 1986 and 1988. There have been some changes in personnel and in the methods of performing the functions. One trend appears to be an increasing use of support contractors to provide some project control functions including scheduling, configuration management, data management, and elements of financial operations. The degree of contractor use varies among the Centers but the trend [in 1989] appeared to be growing throughout NASA in all functions and activities in addition to program control. The impetus for contracting out functions was generally attributed to the need for supplementing the limited availability of civil servants. Discussion with one NASA support contractor, however, confirmed that contractors also had the same difficulties in finding skilled personnel in program control disciplines and were faced with a problem of how to train their people and how to sharpen their skills.

In reviewing the list of program control functions with NASA Center personnel, the reviewers found no disagreement that all of the program control functions were required and should be performed on development

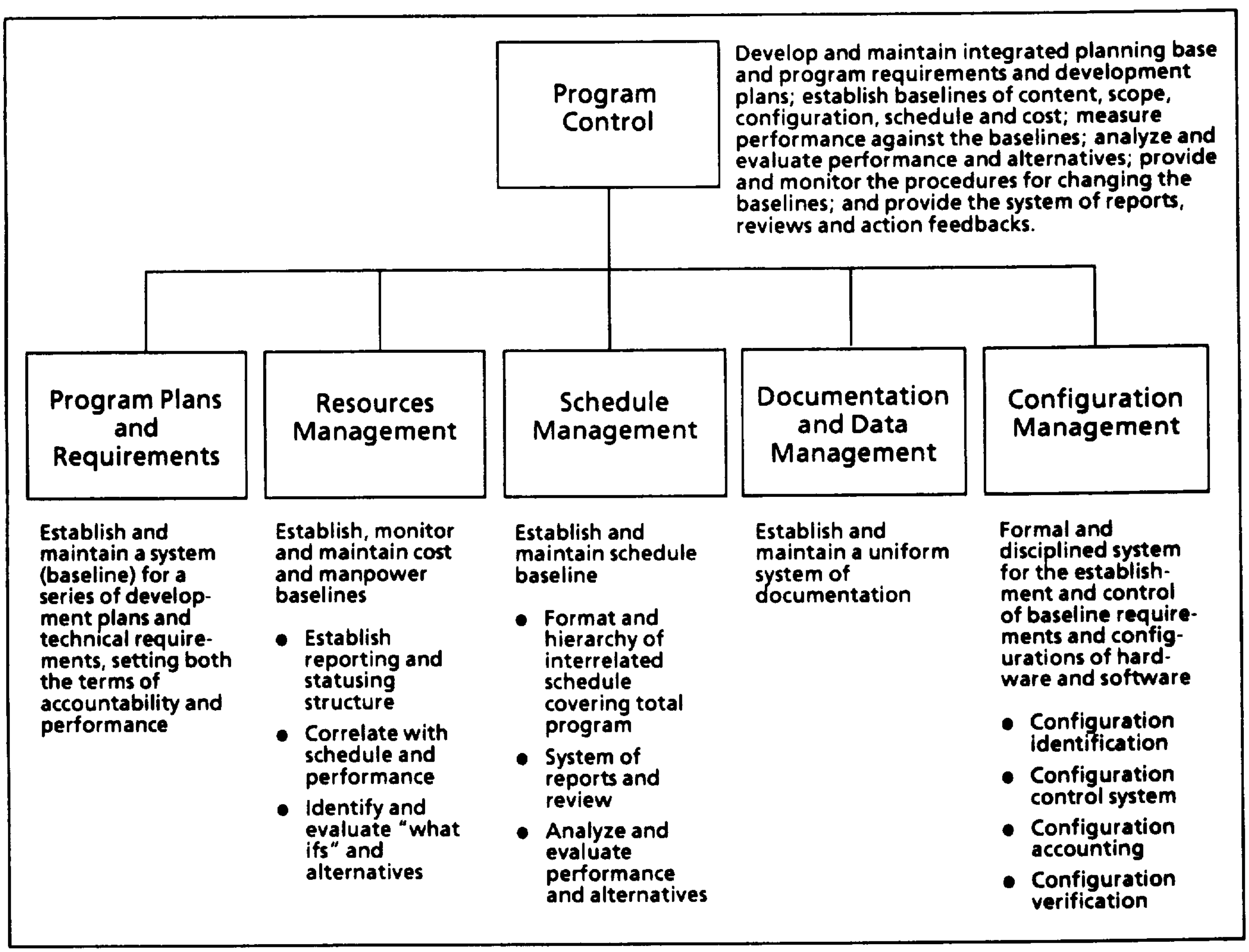

Figure 1. Program Control Functions

projects. Only two organizations had essentially all of the program control functions operating together in one group. At Goddard Space Flight Center the functions were all within the Project Director's office reporting to the Deputy Director for resources. Scheduling, configuration management and data management functions were performed by a support contractor and were under civil service monitors responsible for the functions. A discrete function for project planning was not within the project offices. The Space Station office at Johnson Space Center (JSC) is the other organization having a fairly complete grouping of functions under the program control division. In the other program offices at JSC, program control functions are not integrated in one group but are being performed in one way or another in various organizations.

At the Lewis Research Center, steps have been taken in the Space Station project to integrate resource management, scheduling, and configuration management in a program control organization. At the Marshall Space Flight Center, there is a fairly consistent pattern of combining scheduling and resources management in a single organization in the project offices. Except for the cases noted above, the remainder of the NASA Centers and the Headquarters program offices do not have organizationally integrated program control functions. The functions are either not performed, are scattered in various subgroups, or are done informally.

An Agency cost estimate is always prepared on new development projects prior to evaluation and selection of contractors. However, there does not appear to be a uniform procedure for recycling and validating new estimates after selecting the development contractor. Rather, the contractor's negotiated bid generally becomes the baseline against which any changes are incrementally made. This is true even though the contractor's estimate is usually considerably lower than the government's estimate. The rationale for the government's higher estimate in most cases is quickly forgotten. Credibility begins to be attached to the contractor's estimate, which is neither justified nor borne out by history. Since it takes some time for deficiencies to become apparent they generally come as surprises and result in more costly schedule slippages. In too many cases a large proportion of the time available to the staff of project resource and schedule management groups is spent on finding near-term funding solutions to these "surprises."

As a general observation, too little effort is spent by both resource and schedule groups in analyzing potential problems or risks and in selecting critical reportable milestones that could give some advance notice on the probabilities of problems. Close correlation of reportable schedule and cost performance data is desirable, but the critical indices of performance are not always precisely aligned with a hardware-driven work breakdown structure.

There is an apparent lack of emphasis on laying out logic diagrams or networks on projects, particularly prior to selecting schedule and resource reporting items. The researchers know of no better way to comprehend interrelationships and interfaces of efforts on components, subsystems and systems. When these networks are laid out in time sequence, critical schedule and resource reporting indices become much more apparent and risks are easier to assess. The special virtue of logic diagrams is that they allow planners to incorporate time, resources, and technology into strategies, thus linking temporal horizons with contextual changes.

As a generalization, reviews at the Centers appear to be more structured toward the assessment of project performance than they are in Headquarters. Many of the reviews at the contractor plants, however, seem to be primarily scheduled visits with fixed agendas, and with large groups spending great amounts of time looking at viewgraphs. It was not apparent how often site visits by project control personnel were made for the purpose of assessing performance and verifying the integrity of reported data at its source. Regardless of how scientific the approach or how sophisticated the management system and tools are, there is no substitute for a simple visual assessment. Coordination of those supplying performance data is essential.

Training

Traditionally within NASA, program control personnel have gained skills and knowledge through first-hand experience and from their experienced supervisors. Immersing themselves in program/project research and development activities is still the most common way of gaining project management knowledge. Forming mentor relationships—working with a person who can provide counseling, guidance and advice—is also used to gain the skills and credentials of program control. However, experienced program control personnel are becoming fewer within NASA. According to interviewees at the Goddard Space Flight Center, in the past, many program control staff first studied operations research or industrial engineering, then acquired on-the-job skills and subsequently passed on lessons learned by various means. Rarely did program control staff receive formal training related to specific functions such as the establishment and maintenance of a configuration control or scheduling system.

NASA and contractors currently face difficult problems in recruiting experienced program control staff due to a number of reasons, from limited career paths to elimination of industrial engineering disciplines at many major universities. As mentioned earlier, in response to recommendations from the Phillips Committee, NASA decided to formalize efforts to help in the development and training of managers, including program control personnel. Formal training will be provided in such areas as resources management, schedule management, and configuration management. Analytical skills and the philosophical and logical foundations of program control, however, cannot be learned just by attending classes. They require application and the achievement of an end result as well. Self organization, program interest, ability to coordinate individuals and data, a questioning attitude, resiliency, sensitivity, imagination, and practicability are other nonempirical qualities that are valuable in program control work, but are beyond the realm of classrooms. In sum, formal courses can only complement, not replace, hands-on experience and the inherent qualities of key personnel. This is because analytical skills are, to a large extent, embodied in people and institutions, not just in physical objects like computers.

It is anticipated that formal development training will be provided by both civil servants and contractors. There will be a core curriculum which will be designed to serve business, technical and program and project management staff as well as a series of detailed courses designed for people who will be performing functions in specific areas. It is expected that the importance of integration of the program control functions and synthesis of data, personal responsibility and accountability, and disciplined procedures will be stressed. How the courses are structured and how consistent they are with the past experiences and needs of trainees will have a strong bearing on the prospects for success of the training efforts. Equally important, however, will be the support of top management at the Centers and Headquarters. Their interest will have a serious impact on the outcome of the project. If top management is sensitive to and supportive of the need for training and displays a strong commitment to the training program, the probability of success increases tremendously. Perhaps more significant is that if top management is involved and accurately communicates its involvement, the entire effort will be perceived as credible and worthwhile.

Recommendations and Observations

NASA has successfully managed some of this country's most complex technology and development programs. These successes have included the application of sound program control processes. The basic concepts of program management and program control have not changed, although computerized systems have the capability to enhance the quality and effectiveness of documentation, communications, evaluation tools and support systems. Much of the new capability of tools and support systems have been incorporated in NASA, but over time NASA's use of the basic management control disciplines has weakened. Strengthening program control involves the improvement and utilization of certain disciplines, the existence of a conducive Agency environment and an understanding throughout the Agency of the leadership's policy and objectives. The following recommendations are oriented toward improvements in program control processes and practices.

Enhancement of Agency Environment for Effective Program Control

This study concludes that it would be extremely helpful for NASA personnel to be aware of the importance attached to program control functions by the Office of the Administrator. This awareness can result in the reinvigoration of program management disciplines throughout the Agency. An effective method of informing Agency personnel and contractors would be through appropriate issuances setting forth Agency intentions for conducting its business, expectations of all elements and policies and procedures for program/project approvals, assignment of responsibilities and the explicit accountabilities of organizations and individuals.

The following actions would be helpful:

- Issuance of Agency policies and processes for the approval and conduct of projects, the assignment of responsibilities and the terms of accountability of organizations and personnel.

- Establishment of regular performance reviews against approved baselines of development plans, schedules and cost appropriate for this level of management.

- Facilitation of rapid communications to and from all NASA elements regarding program control functions, tasks and feedback on action assignments.

Development of Training Activities for Program Control

The primary emphasis should be on understanding the role of program control functions in relation to and in context with the program/project manager and other groups and functions of the program office, particularly systems engineering. Systems engineering includes those activities required to transform mission needs into a comprehensive and definitive set of systems performance requirements. It also includes the activities needed to define a preferred systems configuration and its detailed performance requirements. The results of these activities set much of the baseline detail for program control functions including program plans and configuration management and parameters for schedule and cost management.

Program control is the total management process of establishing and maintaining the official development plans and program baselines in a manner which maximizes success in meeting a program's overall objectives. Although the following topics are not all-inclusive, some suggested program control training activities are (more detail shown in Appendix A):

1. Philosophy, content and context of effective program/project control.

2. Planning and documentation of requirements.
3. Content and processes of configuration management.
4. Logic diagrams or networks.
5. The scheduling function and process.
6. Basics of primary methods of cost estimating.
7. Resource management and control.
8. Presentation of data.

The most important element in evaluating and assessing the status of a project and providing program control is the understanding of the objectives, technical content, development approach, and the interrelationships and interfaces involved in its development. Throughout this report, the Academy researchers have taken the position that program control is not a collection of the separate functions that comprise it, but that it is an understanding of the plans and approach and the interrelationships of the functions and performance of configuration, schedule and resource management.

The most meaningful implications from performance data cannot be drawn from the independent functions, but rather, only when the data are integrated. For this reason we have emphasized the integrated understanding of the roles rather than skills and tools. Tools and skills can be very important but only when one understands their limitations as well as advantages and knows when they can be usefully applied. In this context, emphasis on skill training is important with regard to particular tasks such as logic networks, a means of focusing data for the maximum information output and the presentation of interrelated performance data.

Observations

Until conducting this study it had not been apparent to the researchers the degree to which NASA has become staffed with support contractors as opposed to career civil servants. On-site contractors appear to now exceed civil servants. The impact of this condition potentially can have serious consequences on NASA's program management and control capabilities.

As stated earlier in this report, NASA projects push technology beyond the current state of the art. Traditionally NASA has had the civil service and fabrication capability in its centers to conduct the appropriate depth of studies, examine objectives and missions, develop the technical concepts for accomplishing missions, determine feasibility, and provide the conceptual design. If it was decided to budget and contract for the design and development of a project, the inhouse capability existed to manage, technically monitor, evaluate, and direct such contracted work. If technical problems arose at the contractors' plants, the capability existed to help provide solutions and correct the problems. Some of the major objectives of program/project control are the early identification of potential problems, avoidance of surprises, provision of workarounds, and the ability to obtain help in providing solutions. This precept of the importance of early problem identification assumes the availability of the technical capability to participate in solutions to such problems.

Funding pressures on projects have continued since the early 1970s and less funding allowance for the contingencies of the "unknown" has been the result. As surprises occur and additional funds are not available, schedules usually become the variable on which short-term solutions to fiscal year funding problems are based. The obvious result is an increased run-out on total cost and shrinking credibility.

With the increasing contractor staffing, NASA engineers have less and less "hands-on" experience. Service contractors are increasingly being used at Centers to perform project control functions such as scheduling, configuration management and elements of financial management. In effect, this is using contractors to monitor the performance of prime development contractors. This situation is leading some NASA managers to question the Agency's continuing ability to manage contracted projects and control costs.

NASA remains responsible for the performance of the work, but with a reduction in capability to influence and correct performance. How well the Agency meets demands relating to program performance has a major effect on its ability to effectively run programs.

Appendix
Suggested Training Activities

The following topics are not inclusive in the sense that they cover all items.

1. Philosophy, content and context of effective program/project control.
   - What is meant by "control"?
   - An explanation of how the main functions relate to each other.
   - Importance of understanding the totality of the project.
   - Importance of understanding interrelationship of elements and interfaces.
   - Importance of ensuring integrity of reported data to source level.
   - Importance of concentrating on the implications of reported data rather than on the factual data.
   - Anticipation of development difficulties and changes in external environment.
   - Continual assessment of "what ifs."
   - Importance of a questioning approach.
   - Requirement for disciplined processes and positive monitoring.
   - Barriers to effective program control.

2. Planning and documentation of requirements.
   - Importance of maintaining development plan baseline.
   - The necessity of a series of subsidiary plans, actions, and schedules.
   - Documentation of requirements.
   - Technical and program reviews and results.

3. Content and processes of configuration management.
   - Importance of early development and documentation of configuration requirements and preparation of a configuration maintenance plan.
   - The systematic approach of defining and documenting the detailed configuration. Understanding of the need for incremental identification as design and development proceed.
   - The significance of positive control of changes to configuration. Importance of evaluating impact of individual proposed changes on operational capability and total cost.
   - Importance of clear audit trail of changes and maintenance of the exact baseline.
   - Necessity for effective verification that baseline configuration has been implemented.

4. Logic diagrams or networks.
   - Understanding how to develop networks.
   - Importance for understanding the total job and the interrelationship of the components of the job.
   - Relevance of networks to effective analysis and synthesis of performance data.

5. The scheduling function and process.
   - Critical importance of identifying known and potential development risks.
   - Planning for the unknown.
   - Understanding interrelationships and interfaces of development processes and organizations.
   - Importance of selecting the critical indicators of progress or problems – the most important scheduling function.
   - Identification of indicators as far "upstream" as possible from critical progress points.
   - The danger of becoming mesmerized with systems. The need to understand weaknesses better than positive elements and to keep systems as simple as possible.
   - The amount of time required for administrative and decision processes. This time requirement cannot be overlooked.
   - The costliest aspect of a R&D project is time. Slippages are extremely expensive.
   - Emphasis on early problem recognition.
   - Importance of having only authenticated and dated schedules.
   - Maintenance of permanent record of all changes and documentation of slippages.

6. Basics of primary methods of cost estimating.
   - Understanding of concepts, processes, when each is most useful, advantages and disadvantages:
     - Parametric cost estimating;
     - Analogy estimates;
     - Engineering estimates ("grassroots", "bottom up"); and
     - Expert opinion or Delphi techniques.
   - Dangers of accepting contractor's negotiated cost estimate without complete reverification.
   - Importance of quantifying risks.
   - Importance of provision for and use of reserves.
   - Risks involved in using cost goals as incentives in cost estimating and the use of "design to cost" concepts on R&D operational systems.

7. Resource management and control.
   - Establishment of a cost reporting system.
   - Importance of correlating manpower reports on R&D projects.
   - Importance of integrating cost data with schedule performance.
   - Verification of end-to-end integrity of data reported.
   - Understanding the contract structure, and nuances of differences in definitions and accumulation processes of prime and subcontractors.
   - Importance of on-site verification of data and calibration of personnel supplying data.
   - Reporting of data should raise questions, not answer them.
   - Trend analyses.
   - Emphasis on run-out and cost to completion.
   - Importance of continual work on "what ifs."

8. Presentation of data.
   - Determination of objective or purposes of presentation: What is the message or information to impart?
   - Determination of desired outcomes.
   - Avoidance of reams of cost, schedule or engineering data. The need to focus presentations and use only data which contribute to understanding context, significance and implications of information. Detail can overwhelm strategic choices.
   - Factual data may or may not be significant to future actions or decisions even though they may be important for legal or audit purposes.
   - The need to sequence messages in a priority, logical or temporal order. The use of unambiguous language.