Career Development for Project Management

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NASA is experiencing dynamic change with a new emphasis on cost consciousness, increased participation with other government agencies, and more opportunities and requirements for international partnerships. Additionally, the explosion of scientific and engineering knowledge necessitates the pooling of resources from different disciplines, and capitalizing upon the synergy found in well-functioning teams.

These changes and the new skills needed by contemporary project managers present significant challenges to NASA concerning the management of its programmatic, technical and human resources. To address these challenges, NASA commissioned the Program/Project Management Initiative (PPMI) to develop leaders in project and program management. A study was initiated in the mid-1980s by the PPMI to identify the key requirements of NASA project and program managers. Many senior project managers participated in establishing the current educational curriculum. However, a foundation based on the current organizational environment was needed to continue building PPMI programs and activities. Thus, a full scale Career Development Research Study was launched to create an empirically based foundation for PPMI.

Although NASA Centers have implemented career development programs, some of which target project management personnel, an Agency-level program designed within the context of the strategic objectives of NASA and the PPMI was found to be necessary. Participation of NASA Centers' project personnel in the study helped to ensure the applicability of the career development program across the Agency.

Information was gathered from subsystem, system and project managers in NASA to determine what sequence of experiences, responsibilities, education and training are desirable, practical, or required at each point in a career progression. Specifically, this research resulted in four products:

1. Typical career paths of existing project managers.

2. Career recommendations at four distinct stages of professional development.

3. Requirements (knowledge, skills and abilities, experiences and other characteristics) for effective performance at the various levels.

4. Training and developmental experiences that are useful for subsystem, system and project managers.

General recommendations resulting from this study include the following. Entry level engineers and project workers should be involved in hands-on hardware, software and operations activities in a variety of areas. Subsystem and system level managers should have the opportunity to work on a variety of projects and to interface with outside organizations in order to gain a "big picture" perspective. Their training should focus on contractor management (including procurement regulations and contract preparation) and managing people. Project managers should be encouraged to place a heavier emphasis on developing their key people. Project workers at all levels should be encouraged to participate in training courses that cover basic

project management, administrative and interpersonal skills. They should also seek developmental assignments in both technical and resource management. Additional training programs or more modules in existing courses should be developed to address those requirements which are not met by the current curriculum. And finally, a formal development process for project managers should be developed to ensure an adequate skill base on project teams.

Career Paths

For this study, a career path is defined as a sequence of job positions and experiences which lead to a specific career level—in this case, the project, program or engineering manager level.

Two main paths and one secondary path exist—two paths through engineering and project organizations (the majority of the sample worked in one of these organizations) and one path through a program organization, respectively. A barometer of approximate years of experience held by interviewees for certain positions should be interpreted with caution. They should not lead an observer to conclude that they should attain a specific level job by a certain amount of years of experience.

Career levels describe the types of jobs held by interviewees, and were assigned using the following definitions:

- Entry level worker
  Non-supervisory worker in first job with no previous experience
- Mid-level worker
  Non-supervisory worker with 1 to 3 years of experience
- Journey level worker
  Non-supervisory worker with 4 or more years of experience
- Journey level worker
  Non-supervisory worker with 4 or more years of experience
- Expert/master
  Lead technical expert with 10 or more years of experience; includes principal investigator
- First line supervisor
  Section chief, group or team leader, or first position of leadership (10 to 20 years)
- Middle manager
  Branch, deputy division or division chief, system or subsystem manager (15 to 25 years)
- Upper manager
  Project manager, deputy director or director, assistant or deputy administrator, and all other senior management positions (20 to 30 years of experience)

For an entry level engineer, hands-on hardware development was the most frequently experienced responsibility. As one moves up the path in either an engineering or a project organization, one quickly takes on contractor management as a main responsibility. As one moves toward upper management in either engineering or projects, contractor management duties consume less time while project planning and advocacy become the main responsibilities.

The vast majority (about 75%) of senior managers started as entry level engineers in an engineering organization. A few began their careers in a project or program office, or in other organizations such as an administrative or operations organization. A large percentage of the sample started their careers at NASA, although a few began careers in either another government agency or private industry. By the middle career stages, the entire sample worked for NASA; no one in the sample entered NASA at an advanced career stage from outside.

Most interviewees migrated toward a project organization. Approximately half of the sample is represented in the top blocks under a project organization in Table 1 (see foldout). A significant number (35%) also remained in either an engineering or a program organization. A minority (15%) of interviewees moved back to an engineering organization after working in a project office, or moved back to a project office after working in a program office. Several lateral moves did occur. A worker would often move from one engineering job to another, or from managing one project to another.

Career Recommendations

For up-and-coming project managers, interviewees recommended job positions, associated responsibilities and general advice for four career stages. These results tend to be autobiographical, reflecting the career paths to some extent. Interviewees tended to recommend experiences which they followed. Since these experiences led them to the position of a project or engineering manager, it appears they deemed their choices as successful. However, these recommendations also illustrate the lessons learned and reflections on NASA's changing environment and culture from seasoned and respected interviewees and thus are directed toward the future.

Job positions for each stage include several alternatives. Accompanying the positions are responsibilities which interviewees considered to be integral to professional development. The order of responsibilities was determined by how frequently they were mentioned by interviewees. Advice was spontaneously given by interviewees throughout the interview process. Independent of the job positions and associated responsibilities, this advice lays out universal guidance for pursuing an active and successful career.

Stage I: Getting Established. For this stage, an engineering position was recommended by the majority of interviewees. The particular specialty of engineering does not seem to be important; broad experience is the key. The responsibility most closely associated with these positions is hands-on hardware experience. As one progresses through a career in project management at NASA, one will have increasingly less exposure to actual hardware, and will be managing hardware systems from a considerable distance. Therefore, familiarity with the design, building and testing of hardware early in one's career in essential.

Along with hands-on hardware work, general experience in all phases of the project life cycle is also recommended. Since a project manager serves as a generalist rather than a specialist, familiarity with the entire project process is important.

Activities involving communications are highly recommended, including writing reports and making presentations. Later on in this report, in the Job Requirements section, communication is described as one of the most important skills for a project manager. Experience in this area is therefore excellent preparation for a career in project management.

Since the future of the work place will rely on information technology, responsibilities involving computer tools are necessary. A vast array of new software has been produced to aid project managers in building and tracking schedules, budgets and tasks. Awareness and understanding of computer tools will enable one to remain current with state-of-the-art technology relevant to project management.

The advice given for this stage reflects its name *getting established.* Interviewees recommended that entry level workers seek a

breadth of experience, learn as much as they can from as many sources as they can, and work on developing a competent and trustworthy reputation. Interpersonal skill and teamwork were also mentioned. These skills are among the most important for a project manager, as described in the Job Requirements section. Establishing these skills early on is critical.

Stage II: Independent Contributor. Job positions in this stage are either lead technical experts or first line supervisors. They assume an established technical knowledge base and an ability to direct and manage technical work.

Contractor management and technical oversight were overwhelmingly mentioned by interviewees as key responsibilities during this stage. NASA's heavy reliance on contractors necessitates time consuming administrative activities and effective integration of contractor activities with in-house work. This integration concerns technical as well as interpersonal issues.

Budget and schedule management are integral to the management of projects; both have received increasing attention and scrutiny. Responsibilities in these areas are quickly gaining importance. Some hands-on technical work (i.e., hardware design and testing) is still encouraged. Outreach activities such as public relations and meetings with outside groups begin to be a part of one's major responsibilities.

The advice in this stage reflects the transitional role of workers who are moving from a technical position to that of a manager. Continuous development of expertise is recommended. However, emergence as an overseer is strongly encouraged. Visibility can be achieved through many avenues—making presentations, attending meetings and working on critical assignments. Taking risks is part of becoming independent and shows initiative. Pursuing educational opportunities such as degree programs and Agency training courses indicates that a furthering of one's career must be accompanied by conscious effort for redirection.

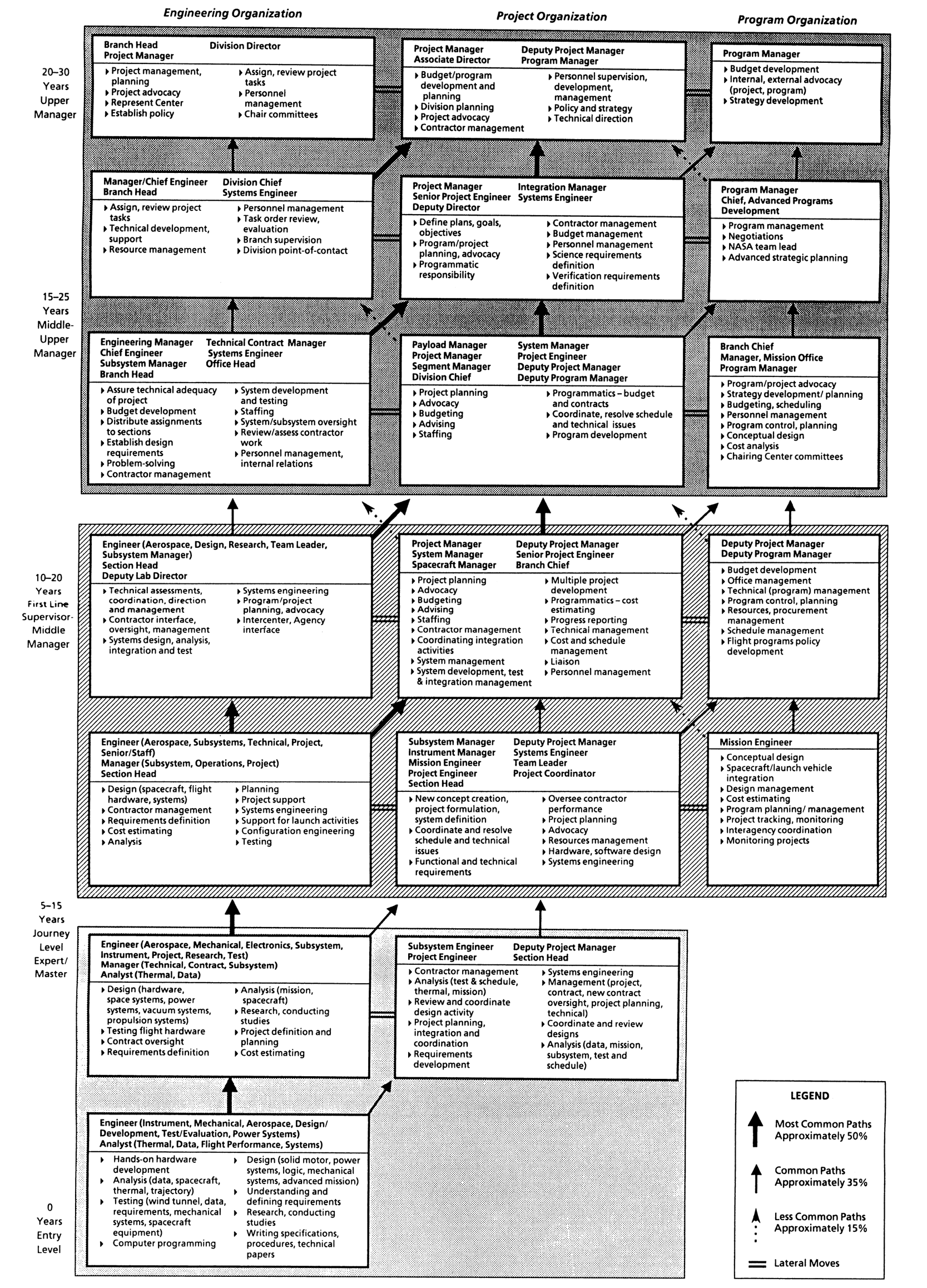
Stage III: Technical Lead/Manager. Job positions in this stage are mostly managerial, yet they still contain variety. A worker in this stage could be managing a system or subsystem of a spacecraft, managing costs of a project as a program controller, or managing technical experts in an engineering organization as a section or branch head. Only one position mentioned, chief engineer, serves as a technical expert.

Responsibilities in this stage are very similar to those in Stage II—contractor management, technical oversight, and general project management. The difference is that the degree of responsibility is increasing. Preparation for major events such as project reviews and launches appears as an integral part of one's job. These responsibilities reflect an emergence of the global nature of a project or engineering leader.

The advice in this stage reflects the evolution of more extensive responsibilities—developing a big picture perspective and interfacing with groups outside of NASA. Technical expertise is assumed to have developed by now. Familiarity with higher level activities and serving as Center and Agency liaisons will provide the seasoning necessary to move into the fourth career stage. Lateral moves were recommended as a vehicle to gain diverse experience.

Stage IV: Organizational Sponsor. Job positions for this stage reflect responsibility for entire projects, programs or organizations. They entail not only management of internal technical and human systems, but outreach, advocacy and leadership.

Career Paths for Project Management



Project control and oversight, mentioned by an overwhelming majority of interviewees, encompass many activities, all of which are of a global nature. A worker at this stage is mostly removed from the day-to-day technical arena. Contractor management, budgeting and scheduling, while still significant responsibilities, consume relatively less time. Setting goals and objectives, generating plans and formulations, and defending major decisions and requests make up the largest part of one's job. Attention to people is also of utmost importance. Motivating and developing employees are integral to project success, and they become the responsibility of top management. Other responsibilities that were mentioned (chairing reviews, making presentations and negotiation) all indicate the advocacy nature of this stage.

The advice for this stage includes seeking responsibility for managing a major project, which is the essence of a project manager's job. The key word is "major"—large projects often bring visibility. Mention of visionary leadership indicates having foresight and mobilizing resources to prepare for the future. Finally, developing key people is recommended in order to strengthen the work force continuously and to ensure a successful future for the Agency.

Job Requirements

Job requirements are the knowledge, skills and abilities, experiences and other characteristics which underlie effective job performance.

Job requirements are reported for subsystem, system and project managers. Subsystem managers include workers who had responsibility for managing a defined portion of a physical system. System managers include workers who manage a larger portion of a physical system. Project managers include workers managing formal projects, as well as upper level engineering managers who are highly involved in the project arena. Definitions of each of these job levels may vary by Center.

The job requirements for subsystem, system and project managers are listed in the order of how frequently they were reported by interviewees; those high on the lists were reported more frequently than those which are lower on the lists.

The job requirements reported by subsystem, system and project managers mirror the responsibilities and advice obtained for the four career stages described in the previous section. In summary, system and subsystem managers report the necessity of mostly technical knowledge, the need to act independently, to take initiative, and the ability to admit lack of knowledge or skill in order to learn and develop. They also cite a diversity of experiences as influential in becoming successful. This reflects the responsibilities and advice given for earlier career stages. Project managers report a heavy emphasis on understanding the political environment and gaining experience with outside groups and organizations, reflecting the global nature of responsibilities mentioned in Stage IV: Organizational Sponsor. The fact that the requirements reported by subsystem, system and project managers reflect the hierarchy of responsibilities and advice for the four career stages lends validity to the findings.

Despite the differences in responsibilities at different career stages, requirements reported for all three groups are very similar. Although workers at earlier levels emphasized technical knowledge more than project managers did, all three groups reported that interpersonal skills are necessary for successful project management. Technical skills are reported as secondary.

Knowledge. Knowledge mentioned by subsystem and system managers was overwhelmingly technical, specifically relating to hardware and technology. Project managers mentioned the political environment as the most important kind of knowledge for their jobs. This outcome complements the finding that advocacy and outreach are among the project manager's chief responsibilities. Although technical knowledge is a basic necessity, political wisdom is imperative.

Skills and Abilities. Teamwork, communication and managing people were reported by an overwhelming majority of interviewees in all three groups. Furthermore, interviewees included in the definition of *team* not only those directly reporting to them, but members of Headquarters, top management, procurement and contractors as well. These interpersonal skills were mentioned in much greater frequency than any technical skills.

Communication. Broad communication skills are integral to building an effective team. These skills are often overlooked since little formal training is usually received. Clear, precisely written documents (e.g., statements of work, requirements) are crucial to successful projects. Communication of current events and problems are critical in overcoming obstacles, which are always plentiful. Finally, communicating the big picture to employees is important in enhancing their contributions to the overall project.

Planning. Planning in all areas was given much emphasis. The need for up-front planning and its ability to save costs and avoid problems later was stressed. Contract management, as mentioned earlier, is skill key in an Agency with high contractor involvement. The remaining skills and abilities reported by all three groups include program control (cost estimating and scheduling) as well as general management activities such as problem solving and conducting effective meetings.

Experience. Subsystem managers emphasized the importance of a diversity of experiences that involve hands-on hardware development. They also indicated the need to carry some technical leadership in order to advance one's career. Experience for system managers focuses on obtaining broad experience primarily through rotation programs. Specific experience in flight projects was mentioned as a key activity. Experience for project managers addresses the diverse activities needed to prepare for global responsibilities.

Other Characteristics. Subsystem managers indicate the need to act independently and seek increasing levels of responsibility. The characteristics most frequently mentioned by all three groups were accountability, responsibility and ownership; a project manager must avoid placing blame on others and be willing to share credit for successes. All of these characteristics are not easily developed through training, but are either innate traits or cultivated through socialization and experience. Furthermore, these characteristics were perceived as an ideal for project management workers at all levels; reality often falls short of this model.

Training and Developmental Experiences

All three groups reported that experience is critical to developing strong and useful knowledge, skills and abilities. Similar to the recommended job responsibilities cited in the Getting Established and Independent Contributor career stages, assignments in a variety of disciplines and projects was deemed as beneficial.

All three groups reported that management support of training was important to their development. Managers who offer support and who value training are integral to developing NASA's work force. Managers who give employees autonomy and the opportunity to excel tend to promote worker ability and confidence. Finally, respondents expressed appreciation for senior managers who act as mentors.

Job Requirement Drivers. For this study, a job requirement driver is defined as an aspect of NASA that facilitates the development of the knowledge, skills, abilities and experiences described in the previous section. In other words, a driver enables a worker to acquire the knowledge and skills which will lead to successful job performance and advancement.

Subsystem, system and project managers described NASA culture and management as sometimes acting as restraining forces. Parochialism and competition among Centers, unclear roles and responsibilities, plus a lack of use of project management tools were cited as barriers to development and career progression. A lack of formal career paths was particularly mentioned as a problem. Concerning management practices, unfair reward and recognition procedures, as well as a lack of mentoring, were related as being obstacles. Finally, lack of time and budget for training courses was mentioned as an impediment.

Valuable Training and Programs. The interviewees were asked which types of training and developmental experiences helped them develop the job requirements described previously. All three groups reported that on-the-job training and experience was most essential. Specifically, hands-on hardware experience and participation in interdisciplinary and inter-Center teams was mentioned as valuable.

Several formal training opportunities were cited as beneficial. These include courses in project management, procurement, and personnel; Agency programs such as the Management Education Program and The Human Element; and rotation programs such as Headquarters' Professional Development Program and Goddard's Professional Intern Program. Such an array of endorsed courses illustrates the utility and significance of technical and managerial training.

Needed Training and Programs. Interviewees were asked to report the types of training and developmental experiences that need greater participation and more frequent offerings. All three groups assert that on-the-job training should be coupled with formal courses in order to realize the maximum benefit for professional development. Similar to responses to the previous question described above, interviewees stressed the importance of experience in a variety of disciplines and projects.

The training courses mentioned by interviewees included topics specific to project management, such as cost estimating and performance measurement, but also topics which have universal applicability to all fields. These include writing, oral presentations, computer tools and time management. These results support the notion that a successful project management worker must not only be technically proficient, but administratively and interpersonally competent as well.

Finally, system and project managers urged the creation of a recommended, sequenced curriculum for project managers. This type of structured curriculum would enable up-and-coming project workers to obtain appropriate training and would permit NASA to cultivate a fully developed, maximally effective work force.

Formal Education. Subsystem, system and project managers were asked to report the level of formal education needed to effectively perform their jobs. All three groups reported that a bachelor's degree in a technical field (usually engineering, but possibly math or science) is necessary. An advanced degree (Master's) in either a technical discipline or in management (e.g., Public Administration or Engineering Management) is helpful but not essential. Interviewees asserted that on-the-job experience must be coupled with formal education to achieve maximum benefit.

Project Management Requirements Covered by Existing NASA Courses. Topics in the areas of planning, scheduling, cost estimating and program control are covered at an appropriate level. Technical topics such as hardware design, operations research and mission operations are not covered in detail in the standard curriculum, but are available at local colleges, universities and at special courses sponsored at the Center level.

The areas that need special attention appear to be building project advocacy and managing the NASA political environment; skills related to building a team, communication, creative problem solving, delegation and leadership; and understanding the NASA personnel system. The Program and Project Management Initiative will study the feasibility of realigning the curriculum to incorporate these findings.