Project Planning: Getting it Right the First Time [1,2]

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Abstract—As the number of space flight projects being conducted concurrently at the Jet Propulsion Laboratory (JPL) has increased, so has the need for institutional support for the projects. One area of particular importance to Flight Project success is support during the early project planning/formulation phase. Numerous studies have identified front-end project planning as a key element of project success. This paper describes JPL's Project Formulation Support Team (PFST), which plays a central role in providing the institutional support tools and services for projects during their early formulation phases and ensure they get off to the right start. Finally, potential future trends in project formulation are discussed, including the increasing application of information networks to meet flight project needs, the effects of competition in the selection process for new flight projects, and the increasing use of multi-national flight project teams.

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1. INTRODUCTION

In the past JPL planned and conducted three to five large flight projects at the same time. During that time JPL's institutional management and support systems provided oversight and support for the flight projects. However, during the 1990s, and continuing through the present, the number of flight projects being planned and conducted by JPL has increased dramatically. Over the last few years JPL been simultaneously planning and conducting 40 to 50 flight projects at a time.

As the number of flight projects being planned and conducted by JPL increased, so did the need for institutional oversight and support to the projects. JPL's institutional management and support systems have expanded in response to the increased number of flight projects underway. JPL's institutional support systems continue to evolve as new and better tools and services are developed to manage and support the large number of concurrent flight projects underway at JPL.

While the growing number of flight projects underway at JPL has created the need for more institutional support of many types, it is in the area of project planning that the need for improved support assumes particularly high importance. It is during the project planning process that decisions are made which have far-reaching effects on the flight project's ability to achieve successfully its cost, schedule, and performance objectives.

2. PROJECT PLANNING: LAYING THE FOUNDATION FOR SUCCESS

Many fundamental characteristics of a flight project are established during the early formulation phase of the project, during which many project planning activities are implemented. For example, the Project's overall cost, schedule, and technical performance parameters are defined; top-level requirements are established; critical constraints are identified; initial mission and system trade options are outlined, and their associated costs and benefits; and preliminary technology assessments and technology development and infusion requirements are made.

The flight project planning process at JPL occurs mainly during Phase A, Advanced Studies, and Phase B, Mission and Systems Definition, as shown in the JPL Flight Project Life Cycle in Figure 1 below. The JPL project life cycle is contained in the pink field in the chart. The corresponding NASA project life cycle is shown in the blue field at the top of the chart, while the major project reviews and major project milestones events are shown in the yellow field.

[1] 0-7803-8155-6/04/$17.00 ©2004 IEEE.
[2] IEEEAC paper #1354, Version 1, Updated December 12, 2003

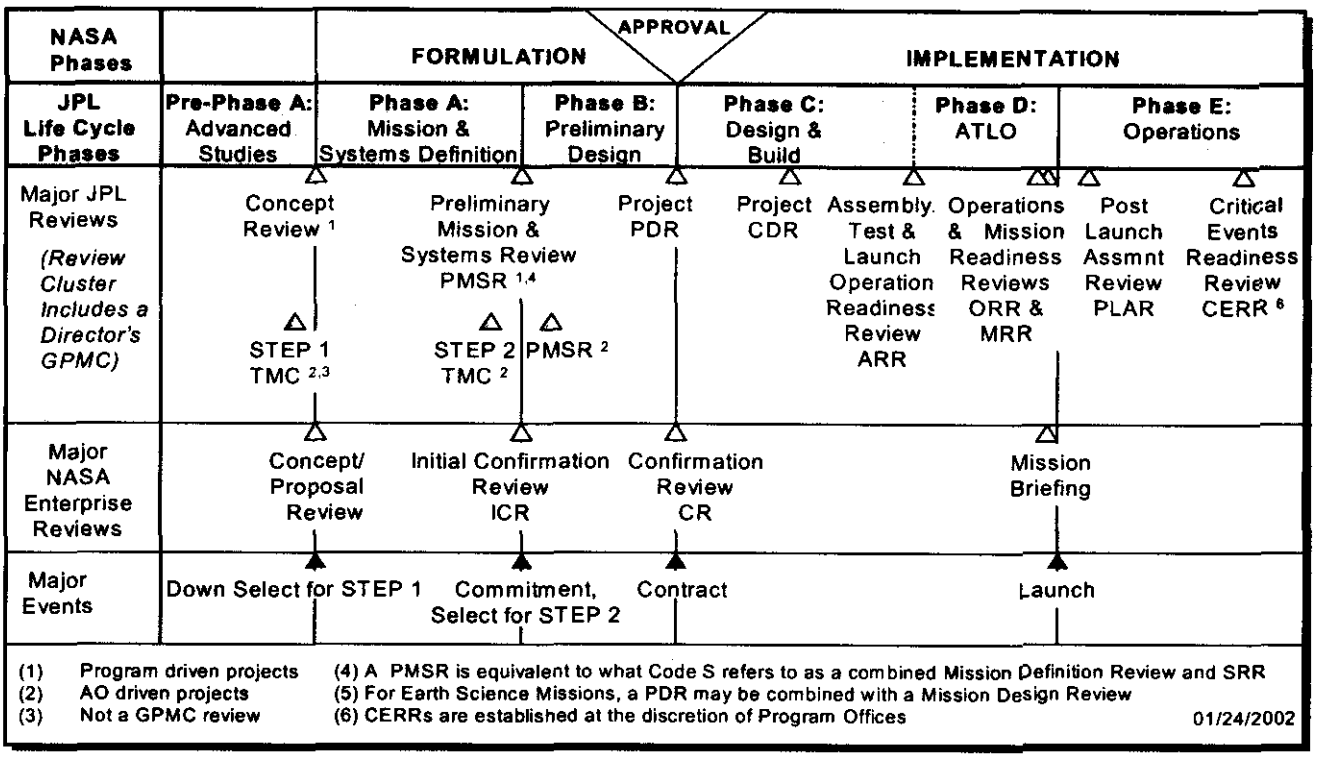

Figure 1: The JPL Project Life Cycle[1]

AO	(NASA) Announcement of Opportunity
ATLO	Assembly, Test, and Launch Operations
CDR	Critical Design Review
CERR	Critical Event Readiness Review
Code S	(NASA) Office of Space Science
GPMC	Governing Program/Project Management Council
PDR	Preliminary Design Review
SRR	System Requirements Review
TMC	Technical, Management, and Cost Review

Project Planning is a Key Element of Project Success

As noted in journal articles, engineering guides, and review reports, robust flight project planning is a key element of project success. Abbreviated or under funded Flight Project planning efforts often create the conditions for later problems, or even failures, in development projects and space missions. For example, an analysis by the NASA Comptroller, cited in the NASA Systems Engineering Handbook, states, "Overruns are very likely if (project) Phases A and B are under-funded."[3]

This is a frequently recurring theme. In the October 2003 publication of *ASK Magazine*, the journal of NASA's

[3] "NASA Systems Engineering Handbook, SP-610S," June 1995, pp. 29.

Academy of Program and Project Leadership, the first lesson learned cited in the article describes the criticality of project planning, as follows: "The seed of problems are laid down early . . . review of most failed projects or of project problems indicates that the disasters were well planned to happen from the start."[4]

In a report on cost growth on NASA missions, the United States General Accounting Office (GAO) cited insufficient definition studies as a reason for cost growth and schedule slips on NASA projects.[5] The GAO report cited two internal NASA studies and comments by NASA officials which specified the need for thorough project definition studies, referred to in this paper as project planning.

Recognizing the importance of project planning, JPL has dedicated significant resources to develop and deploy institutional tools and services to assist flight projects during their early planning stages. A partial list of the tools and services provided by various JPL institutional organizations includes:

- Project planning templates designed to help Projects meet institutional and sponsor requirements and adopt "best practices;"
- Dedicated Proposal Team rooms;
- Collaborative engineering facilities and technical expertise, for example JPL's well-known Team X advanced mission design facility;
- The Flight Hardware Logistics Program, which provides hardware from various sources for use by new projects;
- Project Configuration Management and Project Information Management tools and services;
- Launch Approval/Launch Services tools and services; and
- Project Costing tools and services.

3. The Project Formulation Support Team

JPL's Project Formulation Support Team (PFST) is a key element of the Laboratory's institutional infrastructure which provides support to flight projects. The PFST, like several of the other JPL institutional support systems for flight projects listed above, is part of JPL's Project Support Office. The Project Support Office reports to the JPL Assistant Director for Flight Projects.

At this time the PFST is comprised of 26 members, each with expertise in a discipline or subject area relevant to the Flight Project planning process. The number of members fluctuates over time as people rotate onto or off of the PFST in response to institutional and flight project priorities.

Initialization of PFST Support for a Project

New flight projects entering Phase A are candidates for PFST support. The PFST Manager briefs the Proposal or Project Manager on the PFST's role, and the tools and services which are available. Note that Project Managers are not required to use PFST goods or services; Project Managers decide whether, what, and how much PFST support their projects will use. This arrangement maintains the Project Manager's control of his/her project and provides the Manager with maximum flexibility in how PFST resources are used by the project. In addition, this 'market-driven' approach helps maintain the PFST's focus on its intended role as a service-provider to its customers; JPL flight projects.

How the PFST Works

After the Project Manager decides what PFST support is needed, the PFST Manager assigns a member of the PFST to serve as the PFST Representative for that project. PFST project planning support can continue through the end of Phase C, but support activities taper off as the project's planning efforts are completed in preparation for the project's Preliminary Design Review (PDR) at the end of Phase B.

The PFST Representative assigned to the Project is responsible for coordinating all JPL institutional resources which can be used to help the flight project through the project formulation phase. These institutional resources include the Subject Matter Experts on the PFST, as well as many other non-PFST organizations at JPL such as technical experts from JPL's line organizations, the legal department, and the facilities management division. It is the PFST Representative's job to help the flight project define its project planning needs, and help identify and bring to bear the JPL resources available to meet the needs.

Delivery Options for PFST Services

PFST-provided tools and services are provided at no charge to the flight projects, as follows:

- Guidance and advice from PFST Subject Matter Experts on a consulting basis;
- Project Planning tools, such as the Planning Templates described above;
- Identification of institutional resources, such as the non-PFST Subject Matter Experts described above.

When a flight project needs more in-depth or long-duration support from a PFST Subject Matter Expert, that person

[4] Jerry Madden, "Lessons From the Dark Side," *ASK Magazine*, October 2003, 32-40.

[5] "NASA PROGRAM COSTS: Space Missions Require Substantially More Funding Than Initially Estimated," United States General Accounting Office, pp. 2, 11, December 1992.

becomes a temporary member of the Project Team. Examples of such work include:

- Developing project requirements and requirements documentation;
- Writing major project planning documents;
- Developing project cost estimates, budgets, or schedules
- Implementing project acquisition plans;
- Delivering project hardware or software; and
- Developing or operating project information management systems.[6]

After the PFST scope of work has been defined, the Representative begins meeting with flight project personnel and other PFST Subject Matter Experts to plan and conduct the work.

PSFT Subject-Matter Experts

The 26 PFST members presently include the following Subject Matter Experts:

- Project Management;
- Systems Engineering;
- Software Engineering;
- JPL sponsor requirements;
- JPL institutional requirements;
- Mission Assurance;
- Flight Hardware Logistics Program;
- JPL Flight Project Work Breakdown Structure Template;
- Project planning;
- Project resource planning;
- Project scheduling;
- Acquisition management;
- Launch approval;
- Launch services;
- Configuration Management;
- Project Information Systems Engineering;
- Project libraries & information management;
- Technology Development and Infusion; and
- Project team development and roles.

The PFST plans to add Subject Matter Experts for Technology Development and Insertion, and Project/Mission Science in the near future. The PFST obtains assistance from other Subject Matter Experts at JPL as needed, either to assist a flight project or to create or upgrade one of the PFST institutional support tools.

[6] Kevin Clark and Ken Van Amringe, "Introduction to Project Formulation Support Team Products and Services," pp 5, August 8, 2003.

4. PFST Roles, Tools, and Services

The PFST provides two basic types of direct support for flight project planning efforts during project formulation phase: tools and services. In addition to direct support of flight projects, the PFST also fills an important role in creating and maintaining JPL's institutional environment. Oversight of the PFST is provided by the PFST Manager, the Planning Office Manager, the JPL Assistant Director for Flight Projects, and the Project Engineering and Management Council.

One of the first things a PFST Representative does is brief the Project Manager on the many sponsor and JPL institutional requirements the project must implement during the project planning phase. From this conversation a more detailed work plan for the PFST Representative and the Subject Matter Expert(s) begins to emerge. The Project Manager, in consultation with the Representative, decides what specific products and service activities the PFST will provide and perform.

The JPL Institutional Project Formulation Process

Part of JPL's response to the need to provide institutional support and oversight to an increasing number of flight projects has been an expansion of the Laboratory's systems for oversight of flight projects. One of the more important is the system of *review gates* which control projects' progression through the *JPL Project Life-cycle* phases illustrated in Figure 1 above. The *JPL Project Life-cycle* process requires that projects prepare and obtain approval of specific project plans before receiving authorization to proceed to the next life-cycle phase. The PFST provides support to projects in meeting the requirements for transition through the gates between Pre-Phase A, Phase A, Phase B, and Phase C of the *JPL Project Life-cycle*. For instance, the PFST provides templates and examples for the required project plans, as well as assistance in preparing the plans. The project planning documents required for these Life-cycle phases and gates are shown in Figure 2 below:

Formulation Products			
Project Formulation Authorization Document (FAD) or equivalent (Projects sometimes assist the sponsor in writing)	Ready to sign		
Project level 1 requirements, including mission success criteria	Draft	Preliminary	Approved
Science payload	Preliminary	Final Selected	
National Environmental Protection Act (NEPA) compliance documentation			Environmental Assessment
Formulation phase support agreements with foreign partners		Negotiated, ready to sign	Signed
Implementation phase Letters of Agreement (LOAs) / Memorandums of Understanding (MOUs) with foreign partners		Draft	Negotiated
Planning Products			
Task Plan (signed)	Phase A	Phase B	Phases C/D
Project Plan		Preliminary ready to sign	Final ready to sign
Project Implementation Plan (PIP)		Sections listed below	Final ready to sign
Project integrated lifecycle network schedules	System level	Preliminary to Subsystem level	Baseline
Kennedy Space Center (KSC) / Johnson Space Center (JSC) commitment for cost of expendable launch vehicle and support services		Not to Exceed	Negotiated Cost
Contracts for key industrial partners participating in the next phase		Negotiated for phase B	Negotiated
Formulation Phase Support Agreements with domestic non-NASA partners		Negotiated, ready to sign	Signed
Support Agreements with other NASA Centers.		Draft	Negotiated
Support Agreements with other Federal agencies.		Draft	Negotiated
Project Service Level Agreements, or Memorandums of Agreement (MOAs)		Draft	Preliminary
Science Management Plan		Draft	Final
Project Library & Master Controlled Documents List		Baseline	
Project Document Tree		Draft	Final
Project Work Breakdown Structure and Dictionary	Draft	Preliminary	Final
Safety Plan		Preliminary	Final

Figure 2: *JPL Project Life-cycle* Gate Requirements Documents

PFST Tools

The project planning tools provided or supported by the PFST consist mainly of tailorable Planning Templates for the project planning products required by JPL or its primary sponsor, NASA. In cases where Templates are not available, examples of project planning documents from past projects are also provided, as appropriate, for each project, to use as models. The following list shows the Planning Templates presently available for use by flight projects in project planning:

- Detailed Mission Requirements Document;
- JPL Design Principals Compliance Matrix;
- JPL Flight Project Practices Compliance Matrix;
- Project Plan;
- Project Implementation Plan;
- Project Work Breakdown Structure and Dictionary;
- Task Plan; and
- Test Plan[7]

While Templates are not appropriate for all project planning activities, the application of Templates where appropriate can significantly reduce the time and expense, as well as improve the quality, of project planning activities. Other benefits include improved compliance with sponsor and JPL institutional requirements, and standardized project planning documents which enhance JPL institutional management's ability to review and approve flight project plans. The decision to develop and use templates is made on a case-by-case basis after consultations among the PFST Manager, cognizant SME, cognizant JPL line organization personnel, and the institutional Project Engineering Management Council.

[7] Charles J. Leising, "Project Plans and Activities During Formulation Phase," pp. 20, October 2003.

PFST Services

The assigned PFST Representative and Subject Matter Expert(s) provides PFST services to projects. While providing support to the flight project, their roles are that of advisors to the Project; the Representative and Subject Matter Experts are not reviewers or overseers. When assigned to a project, they become members of the project management team and therefore act as agents of the project.

PFST Representatives and Subject Matter Experts provide advice to the flight project on a variety of broad subjects, including:

- The overall JPL project planning process and products;
- JPL sponsor and JPL institutional requirements;
- Identification of non-PFST institutional Subject Matter Experts who can address project planning needs in areas such as compliance with environmental laws, security requirements, or export control requirements. [8]

To manage the support process and help ensure success, the PFST Representative documents the commitments made to each flight project with which he or she is engaged. The Representative uses a PFST template to record the products and services he or she agrees to provide to the project, including specific product names or expected outcomes, and planned delivery dates.

PSFT Institutional Role

In addition to directly supporting flight projects, the PFST also supports the JPL institutional environment in several important areas, including:

- Identification and flow-down of external requirements applicable to JPL projects;
- Review and comment on proposed new external requirements;
- Development and maintenance of JPL's institutional requirements;
- Training on institutional requirements, including identification and implementation of the requirements, and application of tools available to assist project implementation of requirements.

Examples of key JPL institutional requirements developed and/or maintained by the PFST include the *JPL Flight Project Practices*, the *JPL Design Principals*, and the *JPL Flight Project Standard Work Breakdown Structure*.

[8] Robert Aster, "Hat Write-up for a Project Representative from the Project Formulation Support Team," pp. 2, October 6, 2003.

The PFST also supports the development and maintenance of project review and status reporting systems used by JPL institutional managers to oversee flight project performance. Examples of institutional flight project status reporting requirements which the PFST supports includes *Monthly Project Status Reviews*, *Quarterly Project Reviews*, *Independent Project Review Boards*, and *Governing Program/Project Management Council* reviews.

5. Future Trends

Current trends in flight project design, development, and implementation will continue to impact the types and amounts of planning support the projects will need. Some of the prominent trends are discussed briefly in the following paragraphs.

Competition:
Use of competition to conceive and select new missions, such as those used by the National Aeronautics and Space Administrations' New Frontiers, and Discovery programs, is likely to continue, and perhaps increase. This will be a source of continuing or increasing demand for flight project planning tools and services, which can save time and improve the results of proposal team efforts. For example, the use of tailorable templates in preparing project planning products makes it easier for proposal teams to accurately capture and describe in the proposals the costs and risks the project will have to address during its implementation phase. Use of the planning document templates also helps ensure that sponsor and institutional requirements are included and properly addressed in the proposals.

Information Networks:
Flight projects increasingly use information networks in most aspects of their management and engineering functions, including project planning. Many of the institutionally provided project planning tools and services have been created, or at least greatly enhanced, through the use of information networks. For example, information networks have enabled the evolution of collaborative engineering activities from teleconferences to videoconferences, to the integration of shared mission design engineering practiced by JPL's Team X.

Multi-national Partners:
Another changing aspect of flight project implementation which has increased and will likely continue is the use of multi-national partners to plan and conduct space missions. Multi-national missions place special requirements on flight projects that need to be factored into project plans from the start. As discussed in the previous paragraph, flight projects increasingly use distributed information networks to enable and enhance engineering and management activities, both locally and over long distances. For projects with foreign partners, such information networks must comply with complex export-control regulations which dictate the

conditions under which information can be shared with the project's non-US team members. Thus, the information network must be able to provide varying levels of access to project data, depending on each user's status. This requirement should be defined early in order to avoid time-consuming and expensive fixes later in the project.

6. SUMMARY AND CONCLUSIONS

Summary

JPL flight projects' use of PFST-provided goods and services is increasing steadily over time, indicating that JPL's decision to increase institutional support to its flight projects is providing needed and useful goods and services. JPL's high rate of success in winning proposals for NASA's competed missions is another indicator of the benefits of JPL's investment in technical support infrastructure, including the PFST. The PFST has evolved to also serve as an effective vehicle for capturing corporate knowledge and best practices at JPL, and applying them to many flight projects and institutional activities.

Conclusions

Several conclusions emerge from this discussion of the JPL PFST. First, the confluence of three trends established the need for increased institutional support for flight projects: a large increase in the number of JPL flight projects underway at the same time, a reduction in the size of flight project budgets which increased projects' need for institutional support, and a growing realization in the aerospace industry that robust up-front planning is a key component of a project's ultimate success. Creation of the PFST was part of JPL's institutional response to these trends.

Second, the ever-increasing focus on project cost control has in turn increased institutional management's need for systems and tools to provide meaningful insight into flight projects' status and performance over the project life-cycle. The PFST plays a key role in the development and maintenance of such systems and tools at JPL.

Third, the PFST is proving to be a good vehicle for identifying and capturing JPL institutional knowledge and best practices. The PFST's Subject Matter Experts are drawn from across the Laboratory and represent many different disciplines. They also represent many organizational levels as well. During weekly PFST meetings the Subject Matter Experts often discuss how best to help flight projects or institutional units meet goals or improve performance. Thus, the PFST provides means for both identifying and applying institutional knowledge and best practices.

7. REFERENCES

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8. BIOGRAPHY

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