REENGINEERING THE PROJECT DESIGN PROCESS

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ABSTRACT

In response to the National Aeronautics and Space Administration's goal of working faster, better, and cheaper, the Jet Propulsion Laboratory (JPL) has developed extensive plans to minimize cost, maximize customer and employee satisfaction, and implement small- and moderate-size missions. These plans include improved management structures and processes, enhanced technical design processes, the incorporation of new technology, and the development of more economical space- and ground-system designs. The Laboratory's new Flight Projects Implementation Office has been chartered to oversee these innovations and the reengineering of JPL's project design process, including establishment of the Project Design Center and the Flight System Testbed.

Reengineering at JPL implies a cultural change whereby the character of its design process will change from sequential to concurrent and from hierarchical to parallel. The Project Design Center will support missions offering high science return, design to cost, demonstrations of new technology, and rapid development. Its computer-supported environment will foster high-fidelity project life-cycle development and cost estimating. These improvements signal JPL's commitment to meeting the challenges of space exploration in the next century.

PROJECT DESIGN

The project design process that is used today at JPL evolved from the early spacecraft missions of the 1960s. Although the missions of the 1990s are highly complex and much larger in terms of personnel and costs than earlier missions, the design process has remained essentially the same. Over time, computer-aided engineering and design have been incorporated into the

Laboratory's subsystem design processes, but not into the system design process.

The establishment of a concurrent design center is necessary to support the Laboratory's goal to develop small- and moderate-size missions for the future and to evolve management structures and processes to implement such missions. The Project Design Center (PDC) will introduce computer-aided design techniques into system- and project-level design efforts, facilitating quicker convergence of the design process, more accurate life-cycle estimating, and faster iteration for design-to-cost methodology.

Concurrent design of the mission, spacecraft, and MOS begins with the study phase, and involves designers from all technical disciplines. In the focused PDC environment, the effects of changing requirements or capabilities among the various functional areas can be quickly assessed; capability, schedule, cost, and risk can be readily understood, and appropriate system-level trade studies can be rapidly accomplished.

The overall goal of the PDC is to enhance JPL's ability to secure approval for new projects and to execute approved projects more economically. The PDC'S specific goals are to

- Support JPL missions with the following characteristics:

  High science return
  Design to cost
  New technology demonstration
  Rapid development

- Perform rapid project design iterations to converge on the optimum technical, cost, schedule, and risk solution

- Provide a computer-supported project-design environment for high-fidelity project life-cycle development and cost estimating

JPL's current method of project design is very design-team intensive, typically involving separate teams for project design, spacecraft design, mission design, MOS design, and science definition, plus several supporting teams. The design teams usually meet weekly, define problems, and assign action items to themselves or subordinate teams. Weeks to months are needed to execute, document, and report on action items, and the resulting documents—memoranda or technical reports—may be 50 to 100 pages long. Most of the subsystem designs and analyses are conducted using computer-assisted engineering and design subsystem design tools. The current project design process is time consuming, report intensive, and meeting intensive—

and is not conducive to rapid design iterations. Furthermore, the process is sequential rather than concurrent, necessitating first the mission design, then the spacecraft design, then the MOS design, and finally the cost estimate. As a result, the process tends to produce comprehensive point designs rather than an exploration of the system-level design space.

The PDC will create a much more efficient environment, replacing the functions of multiple design teams with collocated multidisciplinary design team members who will use networked computer-aided design tools (Figure 4). Project personnel can then rapidly iterate designs using design-to-cost methodology and can more thoroughly explore the design space for various attractive options. We anticipate that with this optimum combination of appropriate facility and equipment, the time required for the project design process can be reduced by a factor of 7 to 10.

The PDC will enable concurrent design of the mission elements—mission, spacecraft, and MOS designers will meet in the PDC as a multidisciplinary team to discuss issues that cross boundaries. Cost, schedule, and technical changes can be readily made in an environment that facilitates efficient execution of design-to-cost methodology and rapid iteration of designs.

Designers working in the PDC will be able to quickly focus on issues that affect all areas of design, since the barriers naturally arising from regularly scheduled meetings and delays in problem resolution will be removed. With its convenient environment of networked design tools—and connections to Laboratory-wide networked tools and databases—the PDC will shorten communication paths and speed design iteration.

The most effective use of the PDC will occur during study/proposal and early project implementation, when numerous, major system-level trades are investigated technically and fiscally. The ability to investigate and exhaust the trade space early in the study and preproject phases will minimize costly changes later in the implementation phase. The PDC can be used for days or weeks for a particular study, with designers focusing their efforts in an environment where all personnel can work together.

To create an environment to support concurrent engineering of a project, the PDC facility will be arranged to

- Collocate members of the multidisciplinary design team
- Facilitate electronic, voice, and face-to-face synergistic communications
- Enable real-time design decisions

- Provide an area for design team meetings

- Facilitate development of project proposals

- 'Enable both concurrent and distributed (off-Laboratory) participation
- Enable design interaction by principal investigators

The PDC's initial capability will provide significant improvements for study managers through full project life-cycle estimating, design-to-cost methodology, rapid design convergence, and concurrent engineering of the mission, spacecraft, and MOS. The process will include automated rapid turnarounds and iterations of the project under study, with the levels of design and costing commensurate with study requirements.

Design process flow in the PDC assumes an interactive, but not hierarchical, relationship among all project design elements. From the initial project design—which includes parameters for planning, cost estimating, design to cost, fabrication, logistics, and project database-flow the cost, requirements, and capabilities parameters governing the mission, spacecraft, and MOS design elements. Cost, requirements, and capabilities issues are worked concurrently at the system level, where design tools will be developed especially for use in the PDC. As a project moves into detail design and fabrication phase-when all the major design issues should be resolved—use of the PDC will diminish. The project's database will continue to be maintained by the PDC and will remain accessible.

Implementation of the PDC requires a cultural change that will embrace a multifunctional project design team. Team members will be encouraged to step out of their normal roles as specialists and operate more as generalists. The emphasis in the PDC will be a system view rather than a subsystem view.

The PDC will undergo a three-year, incremental development cycle, with the levels of capability increasing each year. The first year's activities will be devoted to prototyping. This should allow the subsequent years of design and development of the PDC to proceed expeditiously as JI'L reengineer its project design process.

The PDC offers a unique opportunity to optimize and modernize the Laboratory's method of project development by more efficiently utilizing the skills of the JPL workforce and taking advantage of the computerized tools already in existence. At the same time, the PDC environment will enable JPL to effectively apply design-to-cost methodology, produce rapid cost and design iterations, evaluate and incorporate new computer-aided design tools, and reduce project life-cycle costs.

REFERENCE
Hammer, M., and Champy, J. *Reengineering the Corporation: A Manifesto for Business Revolution,, New* York: HarperCollins, 1993, pp. 31-32.

Figure Captions Casani/Metzger

Figure 1. Reengineering the project design process.

Figure 2. A hierarchical organization.

Figure 3. A parallel organization.

Figure 4. Comparative project design processes.