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Implementing Earned Value Management in a R&D Environment

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JPL was founded in the 1930's as a US federally funded research and development center (FFRDC) developing rocket propulsion technologies for the US Army. During NASA's early years in the 1950's, JPL transitioned into a civilian space agency providing key technologies for space exploration. During the 1960's and 1970's, JPL moved away from its propulsion roots and began to focus on robotic exploration of space for NASA. JPL enjoyed decades of attention and ample funding from the government until the mid 1980's. During JPL's golden age, management was accustomed to financial flexibility and typically not constrained by cost or schedule estimates.

In the 1990's JPL's business with NASA changed because competition for government project funding tightened and there was more focus on cost and schedule accountability. NASA initiated a competitive procurement process for most of their research and development projects. JPL was placed into an arena where they were required to provide formalized proposals to NASA for program approval. NASA began to evaluate proposals not only for potential scientific benefits, but with additional emphasis on financial and schedule analysis.

Also, NASA began to conduct yearly evaluations of JPL's business. NASA's yearly performance evaluation factors included technical quality, innovation, safety, and management reliability. JPL's yearly evaluation by NASA results in an award fee that NASA pays to Cal Tech. Cal Tech's Board of Trustees became concerned when JPL consistently scored well in technical quality and innovation, but low on management reliability.

JPL management conducted a study to determine what the root causes were for unsuccessful cost estimates, and determined consolidation of business operations was necessary. In 1994, the Finance Section was added to JPL's organization. Previously each directorate at JPL housed its own business personnel: redundancy was present, and standardization of business processes uncommon. The new organization was chartered to standardize business financial management processes. Although most of the personnel in this new section were primarily financial accountants and cost analysts, this newly formed group represented a quantum leap forward.

Initially the finance section sought to assess maturity of existing business systems and standardize best business practices across programs and projects. Unfortunately, initial analysis found that JPL's business controls primarily emphasized funding reporting and generally placed little importance on scheduling. Scheduling typically involved simple milestone charts, not critical path method network schedules. Performance management and cost forecasting were foreign to the JPL culture. Thus, a study project was authorized to help address strengthening business systems.

In 1995, the Institutional Project Management Systems (IPAMS) project was chartered to define, develop, and implement a performance-based management system for JPL. IPAMS objectives were to implement a commercial off the shelf (COTS) project management tool while concurrently developing processes, procedures, and training programs. IPAMS developed cross-functional evaluation teams to help review eight business management software packages.

Vendor presentations occurred based upon scripted requirements to showcase each software package. Evaluation teams scored each vendor, and subsequently down-selected to three. The three packages evaluated included Welcom Cobra, Microframe MPM, and Mantix Cascade. Initially the plan was to implement a pilot program on three different projects. Each project would beta test a different selected product to aid in determining the final selection for overall laboratory use. The pilot program continued with mixed results and then was terminated before completion of beta testing.

Concurrently, JPL was implementing an enterprise-wide accounting software system, Oracle Financial. Cascade was incorrectly selected based upon its technical compatibility with Oracle. The Cascade system was launched and failed within 2 years for several reasons. Years later Cobra was selected as the lab's performance management cost engine.

In hindsight, Cascade's timing was bad because no processes or procedures were in place for earned value management. Training was unsuccessful so personnel were unaware of what was required in such a rigorous process. Also, Cascade was not user-friendly. Thus, getting budgets into the system was cumbersome. Unfortunately, the failed implementation had an unfavorable impact on lab technical personnel because many were discouraged by business management processes, particularly performance management. As a result, JPL subsequently embarked on an uphill battle to define and implement best business practices and procedures prior to instituting a performance management system.

In 1999, a comprehensive business management division was established. The business management division was chartered to improve NASA's view of JPL's business management. Lab management realized they needed to refresh their existing busi-

ness employees with new ideas to change the existing corporate paradigm. JPL sought to introduce talented business personnel through aggressive recruiting. Over the next three years, the size of the business management division tripled. The business division was chartered with responsibilities to improve estimating, pricing, scheduling, risk management and cost control. Here are a few of the key business management initiatives that were added over the next few years:

- Project and directorate business managers were added to help ensure adaptation of best business practices. Business managers are responsible for managing finance, budgeting, accounting, scheduling, and procurement. Business managers ensure business activities are successfully implemented throughout the project life cycle.

- A costing office was added to assist in proposal development and pricing. The Costing office coordinates cost estimating process from initiation through sign-off and submittal, and provides business expertise to ensure that cost estimates are reasonable, accurate, and complete. Additionally, the costing office ensures that risk assessment is appropriately captured and presented to management.

- A project controls section was created to house professional scheduling (PSA) and resource management (PRA) professionals. The project controls section is responsible for improving schedule development processes and developing and implementing standard scheduling practices and procedures. This department was chartered to develop networked schedules using critical path methodology to aid in both management decisions and earned value management.

- A cost management implementation office (CMIO) was added to develop a system description and earned value management processes at JPL. The CMIO section is responsible for developing and implementing an integrated project management system for scheduling, cost estimating, budgeting, workforce data forecasting inputs, performance analysis, and reporting. CMIO responsibilities also include EVM training, cost performance reporting independent assessment, audit support and surveillance.

Implementing earned value management as a core process at JPL required a complete culture change to the laboratory that was a significant paradigm shift. In order to understand the depth of this culture shift, one must understand the nature of JPL's business and organizational structure.

JPL has a matrix-based organization structure that is mostly focused around executing scientific mission projects. Key staff required to execute scientific missions are pulled across multiple functional organizations and come together throughout the project lifecycle from formulation through implementation.

JPL's matrix organization is comprised of three functions: programmatic directorates and project offices, technical divisions, and administrative operations. The programmatic directorates manage projects and are the main client interface with NASA. Project offices are mission-oriented, and have established task order responsibilities and clearly defined periods of perform-

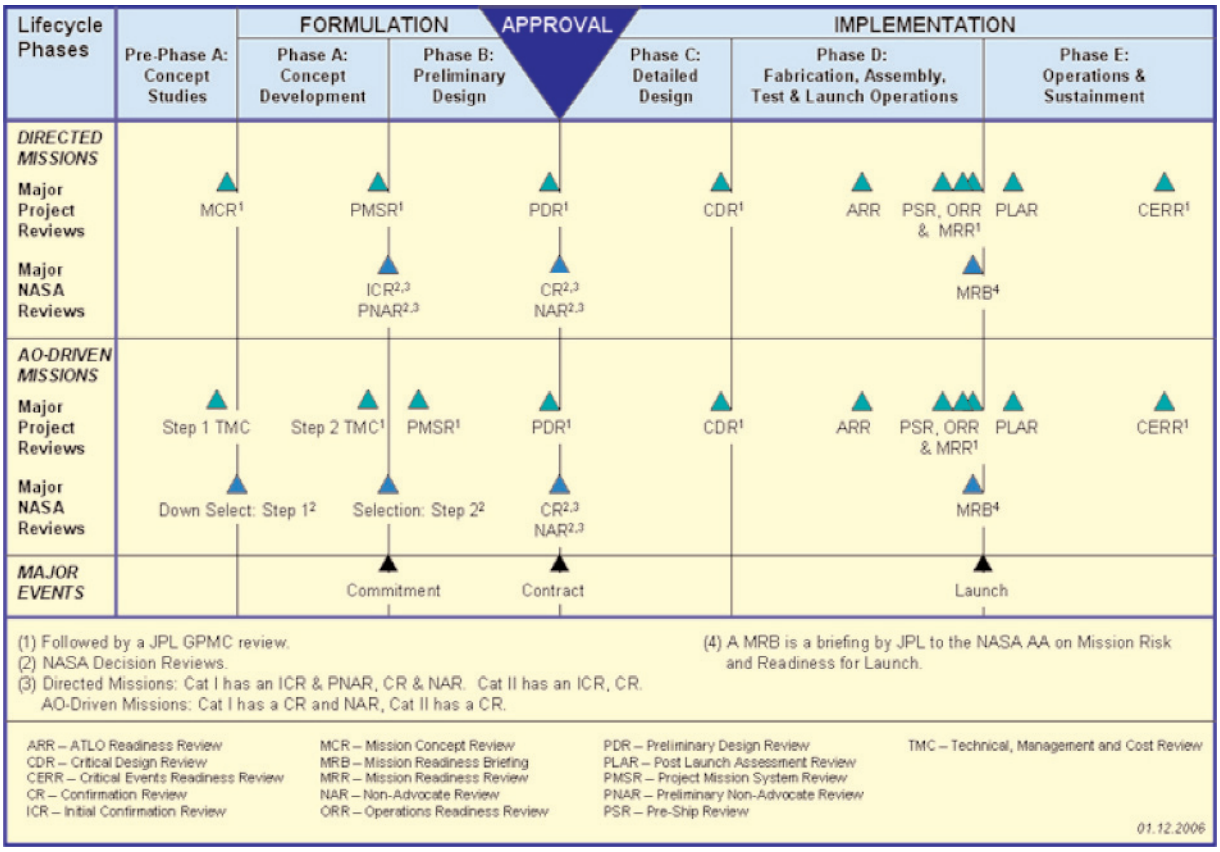

Figure 1—Lifecycle Phases

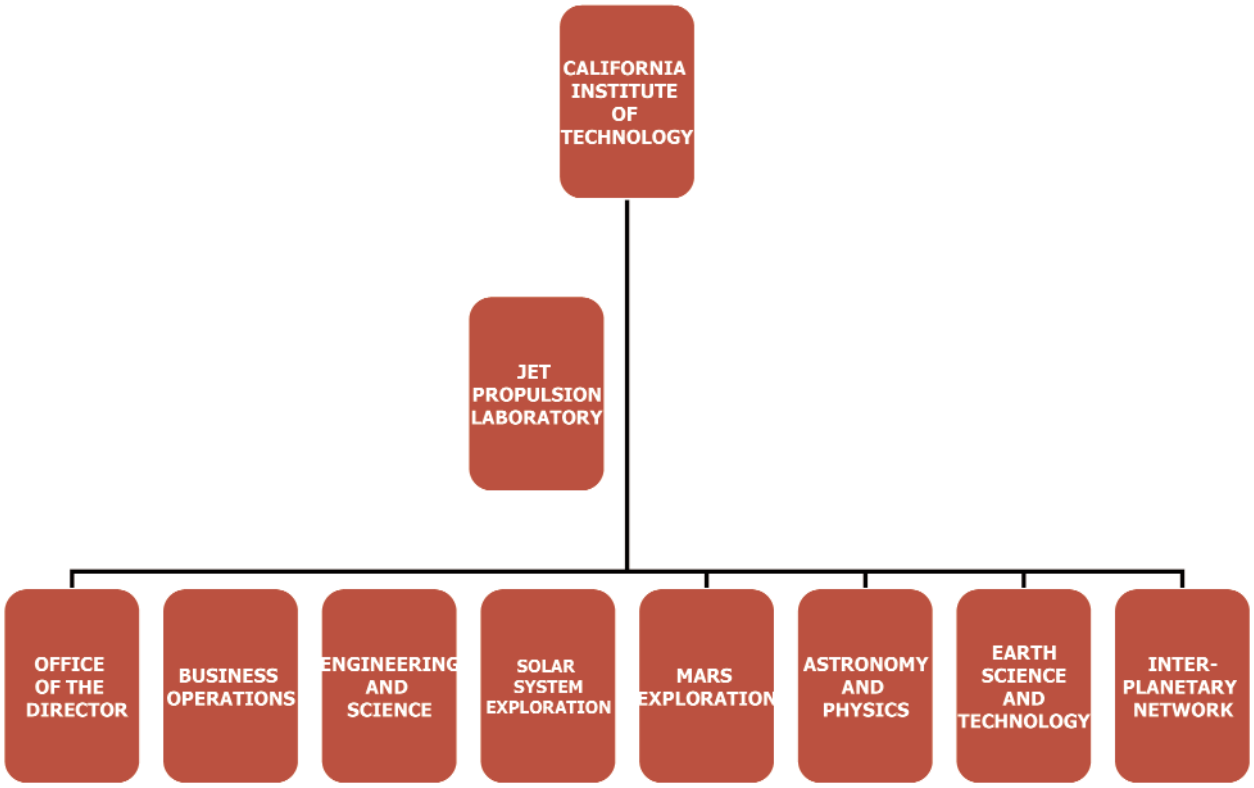

Figure 2—Directorate Structure

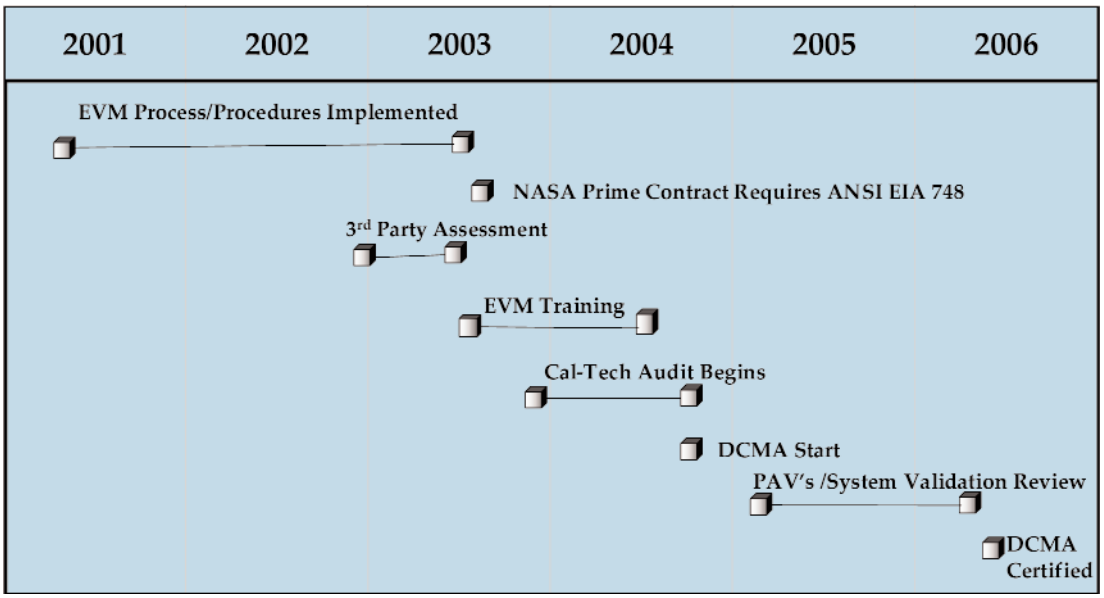

Figure 3—JPL EVM Timeline

ance. Technical divisions supply personnel to projects with technical abilities required for project implementation and ensure availability of required skills. Administrative operations provides administrative support in the areas of human resources, finance, project accounting, program and project business management, acquisition, contracts, logistics, facilities, business computer systems, and other business functions.

JPL's organization structure is divided into nine directorates. Five of the nine directorates are product-line based and the remaining four directorates contain staff organized by function to support projects. The directorate structure is listed in figure 2.

Since the nature of JPL's business involves executing scientific missions, the institutional focus is to meet technical scientific objectives possibly at the expense of business requirements. This results in a corporate environment that is quite structured and very hierarchical. JPL's corporate structure although beneficial for scientific project execution, is sometimes seen as rigid because line organizations are viewed as having more power than projects.

Institutional change is also slowed by the fact that JPL technical personnel are highly educated. Approximately 31percent of all employees hold doctorate degrees, 31percent hold masters degrees and 31 percent hold bachelor's degrees. Statistically,

Area	Audit Finding	Corrective Action
Scope	1. Scope authorization not reconciled to performance measurement baseline (PMB). Responsible organizations not aligned between work agreements and PMB. 2. WBS, WBS Dictionary and Scope Agreements not aligned with schedule milestones and deliverables.	1. Run periodic metric exception reports to identify CAM organization changes and realign PMB. 2. Append scope agreements with relevant baseline schedules.
Schedule Management	1. Poor schedule practices allowing open ends and heavy use of constraints. 2. Duration based percent complete used for measurable accounts. 3. No comparison logs for monthly status and schedule changes.	1. Run periodic schedule health checks to validate schedule integrity. 2. Utilize weighted percent complete. 3. Maintain monthly schedule changes log.
Earned Value Management	1. Lack of defined and documented criteria for measurement in measurable work packages. 2. Commingling of labor, procurement and services in work packages. 3. Overuse of LOE with measurable work packages.	1. Develop measurement guidelines for assessing schedule progress. 2. Limit commingling. 3. Primarily break out LOE work into separate cost accounts.
Inventory Controls	1. Need system in place to track and account for material and residual inventory.	1. Develop enterprise wide material tracking system to track and cost residual inventory.
Subcontract Management	1. Incomplete analysis of subcontractor data for verification of performance. 2. Contract language lacking for subcontractor EVM requirements.	1. Implement institutional EVM training for contract technical managers. 2. Amend subcontract language to require monthly submission of EVM data.
Service Centers	1. Lack of visibility for service center charges to identify variances at completion.	1. Develop enterprise wide service center tracking system to provide both time phased estimates for service center work and monthly cost and schedule status.
Change Management	1. Procedure needed for documentation of changes between periods and reconciliation of lien list to EAC.	1. Utilize change form to process revisions to EAC, schedules, or budgets.

Table 1—Summary of Findings and Corrective Actions

highly educated have their own viewpoints on how to manage. Also, based on their educational accomplishments they assume they are experts in all aspects of business related matters. Finally, they are resistant to change unless change is mandated top down. These realities often make standardization of business processes more difficult.

Technical staff is accustomed to requesting relief from any business process they deem not explicitly required. Historically NASA and JPL management seemed to sacrifice financial controls in order to achieve breakthrough science.

In 1999, NASA's contract with JPL encouraged earned value management but was not enforced, so projects operated primarily without EVM. In 2003, the NASA new prime contract with JPL required ANSI EIA 748 compliance. Unfortunately, many at JPL continued to argue this only meant "EV Lite."

However, in 2001 the CMIO group recognized the need for a process and plans to develop the earned value management process architecture. CMIO embarked to document institutional business and form the foundation for JPL's earned value management system. A leadership team was established to gather input and incorporate lessons learned. Concurrently, the business division developed standard business policies and procedures to implement best business practices. Existing business personnel were trained in best business practices to improve management skills and enable consistent data reporting.

The CMIO group developed a criteria based earned value management system description that was based upon nine process areas. These nine process areas included organizing, scheduling, budgeting and authorization, accounting, indirect management, material management, subcontract management, managerial analysis, and change incorporation. Some of the basics of the system description involved defining scope of projects including development of a standard product based work breakdown structure and dictionary. Planning and scheduling projects was required utilizing critical path method network schedules. Estimates were required to be time phased so that

resources could be identified consistent with the schedule. Metrics were determined to measure performance with predetermined points of managerial analysis. An enterprise accounting system was established such that costs could be recorded by project and costs were consistent with the previously established budget structure. Policies and guidelines were established for management of indirects, materials and subcontracts. Procedures were established governing the incorporation of changes in a timely manner into the performance baseline.

Upon completion of the system description, the CMIO group conducted a third party assessment of earned value readiness to assess the system current state. Subsequently, the system description was iterated again as tool testing and refinement occurred. The third party assessment served a launch point for progress assistance visits (PAV) by the Defense Contract Management Association (DCMA) and NASA.

Over the next two and a half years, JPL had numerous projects involved in EVM audits. This audit process seemed the catalyst to institute the culture change for the laboratory. Business managers of all of the affected projects were helping to drive the paradigm shift. Suddenly, JPL management understood the implications of the new NASA prime contract, embraced EVM and forced the final holdouts into compliance.

The timeline in figure 3 summarizes JPL's EVM implementation efforts.

A summary of some of the high level findings and their corrective actions that are interestingly quite similar to those findings found in other industry wide validation reviews, are shown in table 1.

In closing, JPL's story for EVM implementation is quite long and unique compared to their industry counterparts. Most government contractors had decades since the 1960's to develop and refine their earned value management system descriptions, policies, and procedures. Companies further benefited by continuously refining and enhancing their EVM processes over time. In addition, industry contractors are typically more disciplined in their earned value implementation due to their accountability for profit. JPL runs a non-profit business so the added emphasis to maximize corporate profit doesn't exist.

JPL has managed a monumental feat to implement EVM and have a validated system in about five years. JPL began with nominal business systems and business management to having the exceptional achievement of a DCMA-certified earned value management system. This is no small feat given the complexity of the organization and cultural resistance to change. JPL emerged as an example of business excellence within NASA, and is working within NASA to improve best business practices across the agency.

JPL plans to further grow and develop institutional processes in support of EVM as they incorporate lessons learned. A study project is currently underway entitled Integrated Business Management Solutions (IBMS). This project is chartered to bring together and consolidate all business related matters into an enterprise wide architecture. JPL intends to improve business efficiency with the new IBMS serving as a framework from which all business management processes, databases, and reporting is achieved.

RECOMMENDED READING

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