Alternatives Analysis for Electronic Portfolio Management Environment of R&D Projects Submodules 1.1 and 1.2

Contract Number: DTTS59-99-D-00443
Task Number: T020005
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January 13, 2004

Prepared for:
U.S. Department of Energy, Office of Science

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1 Executive Summary

PDMLink, a commercial software product, is recommended as the best alternative for implementing the requirements of ePME Submodules 1.1/1.2, Electronic Receipt and Review of New and Ongoing Laboratory Proposals. PDMLink is one of a class of products that are used in industry and government to manage product life cycle data.

This recommendation is based on a comprehensive Alternatives Analysis that is presented in this document. The findings of the Analysis indicate:

- PDMLink can be deployed sooner. An earlier deployment schedule will accelerate the cost benefits identified in the SIM study.
- PDMLink is a commercially-proven software package. Commercially proven software lowers risks associated with deployment and operations and maintenance.
- PTC software is already in use in DOE and other federal agencies.
- PDMLink is user-friendly, both for code configuration and integration with other software packages.
- Although costs do not vary greatly, PDMLink, a COTS package, has a lower project life-cycle cost.

Two major assumptions are critical to the results of this analysis and its subsequent recommendation. First, the estimate that approximately 60 percent of the approved requirements will be met by the COTS package and the remaining 40 percent easily added through customization.

- *This assumption is considered valid because there has been a preliminary matching of Submodules 1.1/1.2 requirements to PDMLink, and because PDMLink has an open technical architecture designed for out-of-the-box customization.*
- *Second, each of the major risks identified for the COTS-based approach can be effectively mitigated through technical and project management approaches, particularly for those affecting cost and schedule and the ability to integrate the COTS-based approach with other ePME and DOE systems. This assumption is shown to be valid through the risk analysis conducted in Section 6.3.*

The Alternatives Analysis was performed by Computer Sciences Corporation (CSC) in conformance with the Software Engineering Institute's Capability Maturity Model-Integrated, and DOE guidance as provided by the Chief Information Officer's Software Engineering Methodology and Capital Planning and Investment Control documents and DOE O 413.3 and DOE M 413.3 "Project Management for the

Acquisition of Capital Assets." With these as guidance, CSC used a rigorous methodology to:

1. Identify viable applications among those in use in DOE and in other Federal agencies, and commercial software products
2. Establish criteria and evaluate the products' technical capabilities
3. Conduct vendor demonstrations of potential applications
4. Compare the most suitable candidate application against a custom development effort in terms of costs, benefits, and risks.

The Electronic Corporate Research and Development (R&D) Portfolio Management, Tracking and Reporting Environment (ePME) project was initiated upon acceptance of the findings and recommendations identified in the Strategic Information Management (SIM) process study/business case evaluation completed in 2000. The study, ordered by the Under Secretary of Energy, was co-sponsored by the Offices of Science, the Chief Information Officer, and the Chief Financial Officer; and was conducted in close partnership with all Program Secretarial Offices that fund a majority of the Department's R&D activities. The study was prompted by the fact that DOE funds over $17 billion of energy-related research in a broad range of areas, yet had no central source of reliable data on that research. Shortly after its initiation, the ePME project became part of the DOE e-government strategy in response to the President's Management Agenda. ePME supports the DOE Strategic Plan goal "To protect our national and economic security by providing world-class scientific research capacity and advancing scientific knowledge."

The ePME system, divided into three modules, was originally envisioned as a custom-built system. It includes:

Module 1: Electronic Receipt and Review

Module 2: Electronic Portfolio Management

Module 3: Electronic Program Guidance.

When completed, the ePME system will provide an end-to-end R&D tracking, management, and reporting process that will monitor proposals from award to completion and build a single, automated record for each R&D project.

As a result of a significant lapse in time between project approval and initial funding, the modular approach for system development raised the prospect of initiating a new search for a viable alternative. This time lapse brought the following issues to light:

1. When the system was partitioned into modules to make development more manageable (in accordance with Clinger-Cohen Act guidance), it became clear that although an overall solution might not exist, it was possible that separate COTS/GOTS solutions might exist that would meet each module's distinct functionality and integration needs.

2. Completion of the requirements for Submodules 1.1 and 1.2 resulted in a more detailed understanding of the type of functionality required for Module 1.
3. The technical marketplace had made significant progress since the ePME concept was first articulated in 2000, raising the possibility that a COTS/GOTS application might have been developed in the meantime that could meet requirements on a modular basis.

The alternatives analysis identified 40 candidate applications (Appendix A) comprising DOE, GOTS, and COTS systems. These 40 applications were narrowed to a few choice candidates through a rigorous technical and cost selection methodology, which is described in more detail in Sections 3 and 4 of this report. Ultimately, the elimination process identified PDMLink as the likely alternative solution for Submodules 1.1/1.2, based largely on the requirements identified through workshops held as part of the Business Process Reengineering (BPR) and requirements-gathering activities. A full cost and risk analysis was then conducted between PDMLink and the custom-built system originally envisioned.

Cost estimates for the custom-built and PDMLink solutions were derived utilizing the OMB and Federal CIO Council-approved Delphi estimation methodology and taking into account client imposed constraints on level of effort and release dates. The results are shown in the following table.

Modules 1.1 and 1.2 – Custom versus COTS Costs		
	Custom	**COTS**
Software Development	$5.1M	$3.5M
PDMLink Licenses	$0M	$1.0M[1]
Development Total	**$5.1M**	**$4.5M**
Operations and Maintenance (discounted)[2]	$8.1M	$6.9M[3]
Lifecycle Total	**$13.2M**	**$11.4M**

Other licensing arrangements are possible that could reduce license costs and increase user flexibility. For example, situations within the federal government were found where PTC negotiated costs based upon the number of users as well as peak use, intermittent use, and multiple users per license. All of these situations could complement possible usage patterns within DOE and result in a lower license fee, and therefore, a lower lifecycle cost for PDMLink.

The COTS-based solution offers several important and distinct benefits over the custom solution:

- **Earlier schedule deployment –** Schedule estimates for both systems provide higher certainty that the COTS-based option can be deployed earlier than the custom approach.

[1] The $1.0M figure is a rollup of the $993,600 shown for 1,800 users in table 3-1.
[2] Operations and maintenance costs were calculated for 6 years starting in FY 2005, and discounted using OMB's discount rate of 5.4 % (revised January 2003)
[3] The $6.9M figure for operations and maintenance includes the annual maintenance fee for PDMLink.

Release 1 (pilot deployment) – Both COTS and Custom – March 2004
Release 2 (full deployment) – COTS – October 2004; Custom – January 2005

Note: The custom release dates were based on design beginning in August 2003. Instead, the ePME Project Team informed the Executive Steering Committee (ESC) in October that they were proceeding with a pilot using PDMLink. Therefore, if the ESC decides in January to return to a custom solution, the custom releases will be delayed by 6 to 8 months.

- **Greater development reliability** – PDMLink provides an estimated 60% out-of-the-box functionality when matched against the approved requirements. In the custom approach, all of the functionality would have to be developed and tested. Built-in functionality is more robust and more reliable, having been defined and tested over an extended period of time by a large number of users. This conveys the risk in a schedule constraint environment.
- **Proven vendor technical and support infrastructure** – The vendor will offer substantial technical support and deployment assistance to address technical issues that arise throughout the project. Existing government clients validate this conclusion.

Each of the solutions has risks that must be recognized and managed during the project. These risks affect both the cost and schedule estimates for the alternatives, as well as the potential that they could affect future technology decisions (both in integrating Submodules 1.1/1.2 with other ePME modules and in integrating ePME with other DOE systems). The purpose of the risk evaluation was to identify these major risks, identify their magnitude (likelihood and impact), and identify risk mitigation strategies adequate to reduce the risk frequency and impact to manageable levels. The conclusion was that both alternatives have risks, all risks are manageable, and none are detrimental (in the "red" category). (Refer to Table 6-5.)

The six top risks identified in implementing either the COTS or the custom approaches are the following (in descending order of risk rating):

- **Scope creep** (requirements added late in the development cycle) – This risk rating is higher for a custom solution than for a COTS solution for two reasons. First, the probability of it occurring is greater for a custom solution. Second, if scope creep occurs, the adverse impact is greater for a custom solution than for a COTS solution (risk rating for schedule is 12 for custom versus 6 for COTS)
- **Unexpected technical challenges discovered** – This risk rating is also higher for a custom solution due both to the probability of it occurring and the adverse impact than for a COTS solution (risk rating for schedule is 9 for custom versus 4 for COTS)
- **Difficulty in gaining a business expert's time to provide necessary business information** – This risk rating is also higher for a custom solution due to a

greater adverse impact than for a COTS solution (risk rating for schedule is 8 for custom versus 6 for COTS)

- **Difficulty interfacing with external systems** – This risk rating is higher for a COTS solution due both to the probability of it occurring and the adverse impact than for a custom solution (risk rating for schedule is 2 for custom versus 6 for COTS)
- **Difficulty implementing system upgrades** – This risk rating is higher for a COTS solution due both to the probability of it occurring, and the adverse impact than for a custom solution (risk rating for schedule is 2 for custom versus 6 for COTS)
- **Vendor financial stability –** This risk rating is higher for a COTS solution due both to the probability of it occurring and the adverse impact than for a custom solution (risk rating for schedule is 1 for custom versus 4 for COTS)

In conclusion, using the PDMLink product as the solution for Submodules 1.1/1.2 will accelerate ePME's time-to-value. It brings greater likelihood of earlier deployment and robust functionality for DOE. It accomplishes this objective for a somewhat lower cost and with less risk than the custom solution.

Earlier deployment for Submodules 1.1 and 1.2 is a major DOE management objective. Using PDMLink, Release 2 can be deployed in October 2004, well in advance of the peak workflow period that starts in late January. This provides sufficient time to ensure that all personnel are trained and familiar with the system and the new business process, and any problems have been identified and resolved.

It should be noted that the October 2004 date for going into production with Submodules 1.1 and 1.2 and PDMLink is premised upon two major assumptions. First, resources identified as necessary in the new COTS master schedule to complete Submodules 1.1 and 1.2 are available in the DOE FY2004 budget. Second, there are no procurement delays in obtaining PDMLink.

Therefore, CSC recommends that DOE proceed with Release 1 using PDMLink and following its successful demonstration, continue with PDMLink for Release 2.

2 ePME Background and Overview

2.1 Project Origin

The Electronic Corporate R&D Portfolio Management, Tracking and Reporting Environment (ePME) project was initiated upon acceptance of the findings and recommendations identified in the Strategic Information Management (SIM) process study/business case evaluation completed in 2000. The R&D Council, comprised of the Departmental Assistant Secretaries, and chaired by the Under Secretary of Energy, launched the SIM to determine how best to modernize and streamline R&D management and move toward a corporate R&D portfolio management environment. The study was co-sponsored by the Offices of Science, the Chief Information Officer, and the Chief Financial Officer, and was conducted in close partnership with all program secretarial offices having major R&D activities. The study was prompted by the fact that DOE funds over $17 billion of energy-related research in a broad range of areas, yet had no central source of reliable data on that research. Thus, overall management of DOE-funded research was a difficult challenge. In addition, lack of centralized data made meeting reporting requirements for R&D projects in OMB Circular A-11, *Preparation, Submission, and Execution of the Budget* difficult.

The SIM study recommended the development of a custom-built solution that would encompass the entire lifecycle of DOE R&D projects and allow R&D portfolio management as well as individual project management. The SIM study recommendation was based on finding significant increases in efficiencies over the current, largely manual, business processes for R&D management and a determination that no solution among COTS, GOTS, or in-house software could provide all of ePME's required functionality. The ePME's OMB Exhibit 300 documents the business case and establishes the mission need for the project.

2.2 Project Initiation

The Department of Energy (DOE) ePME project achieved funding in FY2002 and a competitive procurement for its development was awarded to DynCorp in August 2002 (CSC has since acquired DynCorp and with it the ePME project). The original strategy involved selection of an integration contractor to custom-build a modular system that could deliver the required functionality throughout the project's lifecycle. CSC's approach and Master Schedule for developing ePME Submodules 1.1 and 1.2 is based on the original assumption of a custom solution and iterative development.

2.3 Project Description

The ePME project will modernize the Department's R&D project management and administration processes by providing an end-to-end R&D tracking, management, and reporting process. The ePME system will monitor proposals from award to

completion and build a single, automated record for each R&D project that contains information required by DOE R&D managers. The ePME project is part of the DOE e-government strategy in response to the President's Management Agenda. It supports the DOE Strategic Plan goal "To protect our national and economic security by providing world-class scientific research capacity and advancing scientific knowledge."

The ePME vision is to:

- Simplify and unify the Department's R&D tracking, management, and reporting processes
- Enable portfolio management capabilities to facilitate more strategic investment decisions
- Implement the technology solution to support those processes in an electronic, distributed information environment

Table 2-1 lists the goals and objectives for the ePME system.

Table 2-1. ePME Objectives and Goals

ePME Objective	Specific Goals
Streamline processes used to manage R&D across DOE	Reduce annual cost to prepare Field Budget Call response at M&O contractors Increase number of programs able to accept and review proposals electronically Reduce time between funding decision and funds availability to researchers Reduce number of times financial, work authorization, and guidance information require manual reconciliation Reduce number of labor hours required to update research portfolio Reduce time taken by program offices to respond to queries
Improve information availability and utility with respect to DOE R&D projects	Increase number of program offices accessing crosscut or portfolio data on other program office projects Reduce number of times that responses to questions require additional data from research facilities Eliminate the OSTI annual R&D data call to the M&O Contractors for Departmental R&D reporting

2.4 Technical Solution

The ePME technology solution is a corporate information management system that enables the electronic assembly of R&D project management data from across the DOE complex. It is an e-Government application developed to be consistent with the both the Federal and the Department of Energy's Enterprise Architecture. It uses the recommended Component Framework, comprising separate Presentation, Business Logic, Data Interchange, and Data Management components. Security is provided by adhering to Department policies as provided by the security services of the Application Hosting Environment. The software is consistent with the Department's Technical Reference Model. The system is "n-tier", built using Delivery Servers. COTS components and custom code follow the DOE recommendations and approved Standards, including those for XML, J2EE and the Java programming language. It will operate in conjunction with e-government's e-Grants functions. The CSC technical approach is depicted in Figure 2-1.

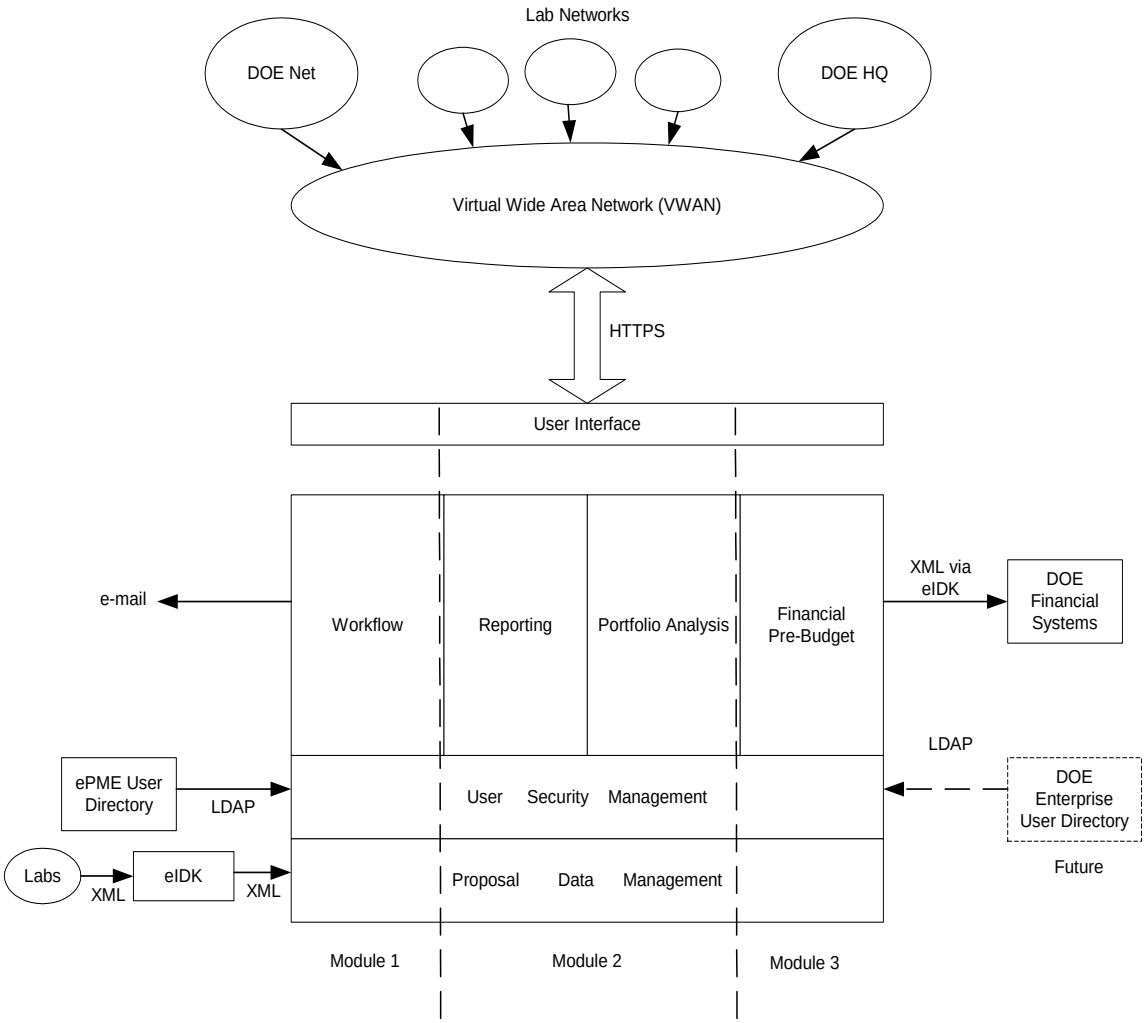

Figure 2-1. ePME Logical Architecture

2.5 Module 1 Electronic Receipt and Review

Module 1, Electronic Receipt and Review, handles the proposal submission, review, and approval process for internal research projects at the DOE Laboratories. After an internal R&D proposal successfully completes the Module 1 process, it becomes an approved research project. Approved grant proposals also are gathered in the Module 1 processing via an interface with the e-Procurement portion of the I-Manage system. Module 1 is planned as the first module to be developed and deployed because of the need to gather information about R&D projects to create an information base of all approved research. Module 1 is also planned to realize the benefits from automating processes that are currently performed manually.

For Module 1, CSC will establish the ePME infrastructure and implement sub-modules of functionality:

- Submodule 1.1 – Electronic Receipt of Ongoing Laboratory Funding Requests
- Submodule 1.2 – Electronic Receipt and Review of New Laboratory Proposals
- Submodule 1.3 – Electronic Receipt of Financial Assistance (on hold because of delays in the development of eProcurement)
- Submodule 1.5 – Electronic Merit Review (on hold because of delays in the development of eProcurement)

Submodule 1.4 dealt with lab-submitted requests for non-R&D funding and was determined to be out of scope.

2.6 Module 2 – Electronic Portfolio Management

Module 2.0 provides project tracking and reporting capabilities and analytical processes for portfolio management. Module 2 supports the R&D project throughout its active life, assisting in the oversight of individual projects, as well as the group of projects in a program. Module 2 analyzes the mix of projects in the R&D portfolio to see if strategic program goals are being achieved. With Module 2, DOE Program Managers will be able to monitor progress, report accomplishments, and guide ongoing R&D projects at national laboratories, universities, and businesses.

Module 2.0 comprises two submodules:

- Submodule 2.1 – Tracking and Reporting
- Submodule 2.2 – Portfolio Management

Module 2 features include: Development of a DOE corporate data dictionary for project reporting, implementation of the project report database, and query agents, Extended Markup Language (XML) data type definitions (DTDs) to enable interfaces with systems at R&D facilities, and related information systems and external resources. Additional XML DTDs will enable interfaces to DOE program-specific management systems.

Development of query templates and standard queries will support program managers' early use of the system. Security interfaces to control access to information are deployed at this time. CSC will provide additional data stores, user interfaces, and data interfaces, enabling ePME to gain significant functions to improve reporting and tracking of R&D efforts.

2.7 Module 3 – Electronic Program Guidance

Module 3 provides work authorization and budget allocation guidance to the DOE Laboratories for approved internal research projects. Module 3 will interface with the DOE I-Manage financial system to obtain budget allocation information. Module 3 was designated as the last Module to be developed because of its dependency on the completion of the budget execution portion of the I-Manage project. Module 3.0 will allow Program Managers to enter funding information and guidance to the laboratories. Combined with workflow software and electronic signature software, it will enable fully electronic project execution.

Module 3.0 will enable the laboratories to report project expenditure data, allowing Program Managers to better able to gauge how well projects are adhering to costs and schedules. In the case of universities, contracting officer in the operations office will have a fully automated project-execution phase which functions in conjunction with the eProcurement system. Module 3 requires significant data interfaces using XML DTDs to provide data sharing among other financial systems.

3 The Alternatives Analysis

3.1 Basis for this Analysis

Due to a significant lapse in time between project approval and initial funding, the system modular development strategy raised the prospect of revisiting the search for a viable alternative. This time lapse brought the following issues to light:

- When the system was partitioned into modules to make development more manageable (in accordance with Clinger-Cohen Act guidance), it became clear that although an overall solution might not exist, it was possible that separate COTS/GOTS solutions might exist that would meet each module's distinct functionality and integration needs.
- When the requirements for Submodules 1.1 and 1.2 were complete, there was a more detailed understanding of the type of functionality required for those submodules
- The technical marketplace has made significant progress since the ePME concept was first articulated in 2000, raising the possibility that a COTS/GOTS application may now be available that meets requirements on a modular basis.

The original assumption was for custom development of Submodules 1.1 and 1.2. To validate this approach, CSC surveyed COTS and GOTS product capabilities. Realizing that viable options were available, CSC proceeded to conduct a formal Alternatives Analysis.

An expert approach was used to conduct this analysis. CSC put together a diverse team of individuals with experience and knowledge in a wide range of disciplines relevant to the analysis, such as ePME functional requirements, Federal and DOE policies, Federal and DOE Enterprise Architecture, COTS development. It then brought in independent experts as appropriate (such as the Gartner Group and other organizations implementing PDMLink) to review and confirm its findings. Cost and schedule estimates were derived utilizing the OMB and Federal CIO Council approved Delphi estimation methodology.

3.2 Key Parameters for this Analysis

3.2.1 Scope

This alternatives analysis identifies and evaluates existing application alternatives to satisfy requirements for ePME Submodules 1.1 and 1.2. The scope is limited to Submodules 1.1 and 1.2 because:

- Requirements are fully defined and approved for Submodules 1.1 and 1.2, and not subsequent modules, in accordance with the ePME Master Schedule

- There is significant value in fast deployment of a key piece of ePME functionality
- Submodules 1.1 and 1.2 provide the majority of Module 1 functionality
- Submodules 1.3 and 1.5 are on hold because of delays in eProcurement development.

3.2.2 Support for Enterprise Integration

Full development of the ePME system requires that the approach to Submodules 1.1 and 1.2 supports a robust series of choices for subsequent modules (i.e., the system is based on integrated components, each of which having the potential to support different types of functionality, yet transparently integrating to create the entire solution.)

Alternatives are evaluated against the DOE Enterprise Architecture and requirements to interface with other DOE and Federal systems.

Consideration is given to standards, established by the Federal Enterprise Architecture Project Management Office's Technical Reference Model, that support eGovernment.

3.2.3 Standards

This alternative analysis is in conformance with the Software Engineering Institute (SEI) combined model named the Capability Maturity Model-Integrated (CMMI), which is used throughout CSC. The particular CMMI component employed is Decision Analysis and Resolution (DAR).

Although the alternatives analysis followed internal CSC standards, it is also in compliance with DOE guidance as provided in the Chief Information Officer Software Engineering Methodology (SEM) and Capital Planning and Investment Control (CPIC) documents.

In addition, DOE O 413.3 on project management was followed as expressed in DOE M 413.3 "Project Management for the Acquisition of Capital Assets."

3.2.4 Disclosure Statement

CSC has a number of relationships with vendors of Product Lifecycle Management (PLM) products, a category that was evaluated in this Alternatives Analysis. The relationships are identified below.

<u>Formal agreement between CSC and vendor (company and product listed)</u>

Dassault Systems – PLM products ENOVIA and SmarTeam (IBM has new product sales rights and Dassault Systems has all consulting and services work)

PTC – Windchill family of products (PDMLink, ProjectLink, PartsLink, etc.)

SAP – all products including SAP PLM

Working relationship between CSC and vendor (company and product listed)

Agile – Agile and Eigner

EDS – Teamcenter

MatrixOne – Matrix

Documentum - Documentum

Note: The majority of the Alternatives Analysis was done under the auspices of DynCorp, prior to its acquisition by CSC. PTC's relationship was not discovered until Step 4 of Phase 1, at which point PDMLink was emerged as the strong front-runner. The PTC-DynCorp relationship was not a factor or influence in the final decision to recommend PDMLink.

4 Methodology

4.1 Overview

The Alternatives Analysis is conducted in two phases. The objective of the first phase is to identify the best candidate Off-the-shelf (OTS) applications from a functional and technical perspective and flag these for further evaluation. (An application is considered viable if it passes all the steps of the evaluation process as discussed in the following paragraphs.) If Phase 1 identifies no viable applications, the alternatives analysis concludes at the end of Phase 1 and the recommended alternative will be a custom-built solution.

The objective of the second phase is to perform a comparison of the costs, benefits, and risks associated with each of the potential OTS applications identified in Phase 1 and the costs, benefits, and risks of a custom-built solution.

4.2 Phase 1 Evaluation

The Phase 1 evaluation process contains several steps that serve as filters to either eliminate applications or pass them on for more detailed evaluation. Each step answers a particular set of questions:

- Step 1 – Does the application support basic required functionality (i.e., for ePME Submodules 1.1/1.2, does the application support general proposal submission and review functions)? Does it appear to be a good choice for the DOE environment? Only the applications with "yes" responses are passed to step 2.
- Step 2 – Does the application feature appropriate technical capabilities? How does it compare with other applications? Only applications with the highest technical capability scores are passed on to step 3.
- Step 3 – Demonstrations. Are technical capabilities present in a robust, flexible, and easy-to-use fashion? Will the application be difficult to integrate with the DOE environment and the rest of ePME? Only applications that appear to have a high probability of success in being incorporated as ePME Submodules 1.1 and 1.2 will be passed on to Step 4.
- Step 4 – Validation. Have the vendor demonstrate the product again using actual ePME scenarios. Consult product experts about the suitability of the product for ePME requirements, how it compares with its competitors, current user base, financial stability of the vendor, future viability of the product. Demonstrate the product to the ePME Federal staff. Visit PTC customers to see the product in action and obtain their opinions of the product and the vendor.

4.3 Phase 2 Evaluation

The Phase 2 evaluation process compares the viable OTS alternative(s) identified in Phase 1 to a custom-built solution in terms of cost, benefits, and risks.

- Step1 – Costs. For the custom-built solution, use the Master Schedule for development costs for the custom-built solution. For the viable alternatives, compute the cost by adjusting the Master Schedule for steps that will be eliminated or changed to accommodate an OTS solution. Add the costs to acquire the OTS solution. Compare the two costs.
- Step 2 – Benefits. Identify a set of possible benefits. Ascertain the probability that these benefits will occur with the OTS solution and with a custom-built solution. Compare the two results.
- Step 3 – Risks. Identify the risks for both solutions, along with the probabilities that the risk situations will occur and the impacts of those occurrences. Compare the two results
- Step 4 – Compare costs, risks, and benefits. Recommend a solution.

5 Phase 1 Evaluation: Identification of Viable Applications

5.1 Step 1 – Initial Functional Screening of Applications

The purposes of Step 1 are twofold:

- Identify candidate applications from three sources: the DOE community, other Government agencies (GOTS), and commercial software vendors (COTS).
- Using a high-level screening process based on the major requirements of Submodules1.1 and 1.2, choose a manageable number of the most likely candidates for further evaluation.

To make the list of potential candidates for this step, two primary questions governed the alternative analysis:

- Does the application provide general proposal submission and review capabilities?
- Considering the capabilities and features of the other candidates, ePME Submodules 1.1/1.2 requirements, and the DOE technical environment, is there an obvious reason to include/eliminate this application?

Step 1 identified 40 candidate applications (see Appendix A for a complete list and short description of each). These candidate applications were evaluated, and 11 applications were chosen via the high-level screening process to pass to Step 2. The 11 applications, comprising DOE, GOTS, and COTS candidates, are discussed in the following paragraphs.

5.1.1 Existing DOE Applications

DOE applications were researched first to identify any available solutions. Two sources provided potential DOE applications. In stakeholder workshops, participants were asked to identify candidate applications that already were in use at their sites. Earlier Collaborative Management Environment (CME) studies identified other DOE applications.

Seventeen applications were identified, and five applications were chosen for further consideration. The basis of elimination for 12 of the applications ranged from applications that did not handle the proposal submission and review process to those that did but were too narrowly focused.

Of the five applications retained for further analysis, four handle the laboratory portion of the proposal submission and review process at their laboratories. The remaining application, EMSL, is used to screen proposals to use the high

performance computing system at Pacific Northwest National Laboratory. The five remaining applications are:

- Environmental Management Solutions Laboratory (EMSL) User Proposal System from Pacific Northwest National Laboratory
- Field Budget System (FBS) from Lawrence Livermore National Laboratory
- Field Work Proposal (FWP) tool from Sandia National Laboratory controller
- Management and Proposal Preparation Submission (MAPPS) from Argonne National Laboratory
- Program Management Tracking System (PMTS) from Lawrence Berkeley National Laboratory Financial Services Department

5.1.2 GOTS Applications

The second area researched was applications in use at other agencies, or Government-Off-the-Shelf (GOTS) applications. Potential GOTS applications were identified from CME documentation, publicly available material on the web, and Oracle Corporation.[4]

In conducting this research, it was realized that DOE is unique among Government agencies with its environment of Government-owned, contractor-operated national laboratories. Other agencies support research through grants or entirely within program-specific laboratories without the same type of proposal submission and evaluation processes. The DOE national laboratories, however, perform research for several programs, routinely submitting proposals in response to program solicitations.

The search for GOTS applications resulted in several GOTS packages for creating proposals, but all of the applications were geared towards submission of grant proposals by external entities. Only one, e-Grants Plus, displayed the capabilities for internal review and response that is needed when working with the DOE national laboratories. However, because other GOTS applications were well-known possible candidates, it was decided in this initial screening process to retain these other applications to demonstrate how they compared to the DOE and COTS applications being considered.

The four GOTS products chosen for further evaluation are as follows:

- eApplication from the Department of Education
- FastLane from the National Science Foundation

[4] Oracle recommended that CSC evaluate DTR in lieu of its PLM product because it was a better fit for ePME requirements.

- NIH Commons from the National Institutes of Health
- STR's e-Grants Plus (formerly GOTS, newly COTS)

5.1.3 COTS Applications

The third area researched was COTS products. Two general types of COTS products were identified as potential alternatives:

- Grant proposal submission applications
- Product data/life-cycle management applications

Both types of products are discussed in the following paragraphs.

In general, applications in the category of grant proposal submission packages proved to have limited functionality relative to the requirements for Submodules 1.1 and 1.2. Their primary capabilities are to provide forms and templates for entering grants application data. None of the applications reviewed in this category offered any functionality, such as workflow, a database, linking of attachments or reporting, all of which are requirements for Submodules 1.1 and 1.2. There also are no provisions made for any type of submission process. As a result of these major limitations, none of the proposal submission applications was chosen for further evaluation.

A second category of COTS products that lends itself well to the broad functional and technical capability requirements for Submodules 1.1 and 1.2 is product data management or product life-cycle management (PLM) packages. These packages are used by private industry for supply chain management and product development management. They generally comprise three areas of functionality:

1. Rigorous and flexible workflow – The workflow features data-driven and/or role-driven workflow with electronic signature and interfaces with e-mail.
2. Document vault – Document management is provided through robust security and version control of a variety of document formats
3. Relational database – The database contains all the metadata for the document vault as well as overview data concerning a particular project

These three areas of functionality map well to the major types of requirements necessary for Submodules 1.1 and 1.2. From the range of applications available, two specific COTS products from this category were chosen for further evaluation:

- PTC PDMLink
- SofTech ProductCenter

5.1.4 Products Chosen for Evaluation

Eleven specific products from DOE, GOTS, and COTS remained for evaluation in the next step. They were:

- Environmental Management Solutions Laboratory (EMSL)
- Field Budget System (FBS)
- Field Work Proposal (FWP)
- Management and Proposal Preparation Submission (MAPPS)
- Program Management Tracking System (PMTS)
- eApplication (ED)
- FastLane (NSF)
- NIH Commons (NIH)
- STR's e-Grants Plus (STR)
- PTC Windchill (PTC)
- SofTech ProductCenter (SofTech)

5.2 Step 2 – Technical Capability Evaluation

5.2.1 Purpose and Key Questions

The purposes of step 2 are as follows:

- To develop a set of technical capability criteria to evaluate whether a candidate application has a strong, technically current foundation that will provide a robust, flexible solution for the basis of a complex DOE-wide corporate system
- To evaluate the candidate applications against these criteria so that the best, potentially successful applications can be identified.

Key questions to be answered are:

- Which applications have most of the required capabilities?
- Are there enough capabilities present in these leading applications for them to be considered further? Do they have any fatal flaws?

5.2.2 Technical Capability Criteria

Laboratory, Field Office, and Program personnel representing 26 DOE organizations participated in identifying the functional requirements for Submodules 1.1 and 1.2. The Executive Steering Committee approved the functional requirements in

November 2003. These requirements serve as the basis for the technical capability criteria.

Using the functional requirements identified for Submodules 1.1 and 1.2, CSC analysts established high-level technical capabilities that an application must have to provide the required functionality for these submodules.

Twenty-two major capabilities in eight categories were identified for these two submodules. These 22 high-level capabilities represent technical characteristics Submodules 1.1 and 1.2 of ePME must meet. Each of the 22 high-level capabilities was deemed equally important in the analysis (i.e., weighed equally). However, missing capabilities for any application that was considered for passing to the next step were further analyzed to make certain that they were not fatal flaws.

Some of these capabilities relate directly to high-level functional requirements (ability to attach documents in several document file types) or relate to whether the application takes advantage of latest technology to provide functionality in the most efficient and effective manner (E-mail interface). Others demonstrate a flexibility to be integrated into several different environments and interface with many other types of software (support access to LDAP, OLE DB, and ODBC data sources).

Identifying the critical high-level capabilities is vital at this stage of an alternatives analysis to screen the larger list of possible applications and identify the few that are most likely to provide a viable solution. These few will then undergo a more detailed analysis.

This part of the evaluation process emphasizes the core strength and potential of the applications in areas that are required by ePME. It is not a matching of functional requirements to see what percentage must be custom programmed.

Specific capabilities that comprise an application's core strength should be designed into an application from the beginning. An application can be missing only a very small number of these core capabilities to be a cost effective, or even feasible, solution to use as the basis for Submodules 1.1 and 1.2.

5.2.3 The Candidates

Information about the 11 candidate applications that were passed to Step 2 for evaluation came from several sources. Information about DOE applications was gathered by having system owners fill out questionnaires. Information about the GOTS products (other than STR) was gleaned from system documentation. Information about STR and the two COTS applications was gathered from interviews with the vendors.

All 11 candidate applications are scored in Table 5.1. Scores represent the percentage of capabilities present (number of capabilities met divided by the total number of capabilities). Based on the results, three products scored greater than 80

percent (i.e., they met at least 80 percent of the 22 high-level requirements.). These were STR Grants, SofTech ProductCenter, and PTC PDMLink.

EMSL scored almost as high as SofTech, but was missing almost 25% of the required capabilities. Among the missing capabilities were the ability to handle an unlimited number of concurrent users and electronic signature capability, two characteristics that were deemed fatal flaws.[5]

The three highest scoring applications, STR Grants, SofTech ProductCenter, and PTC PDMLink, were passed to the next step. (Additional evaluation of these packages showed that there were no other elements that were considered fatal flaws that would have eliminated them from further consideration.)

Table 5-1. Candidate Application Scores

Category/Application	DOE					GOTS				COTS	
	EMSL	FBS	FWP	MAPPS	PMTS	NSF	NIH	ED	STR	SofTech	PTC
Administrative and Security											
User-controlled access rights at the proposal/project level	X	X		X	X				X	X	X
Electronic signature capability						X			X	X	X
Attachments											
Ability to attach documents in several document file types	X				X	X				X	X
Data											
Ability to handle B&R codes		X	X	X	X						
Ability to create user-defined fields	X	X		X					X	X	X
Support formula and scientific notation					X	X	X		X	X	X
Ability to edit and reject data in fields	X	X	X		X				X	X	X
Ability to create new proposals by copying and editing similar previous work	X	X			X				X	X	X
Ability to designate default values	X	X	X	X					X	X	X
End-user interface											
Customizable input screens, help, and error messages	X	X		X					X	X	X
Consistency in look/feel throughout system	X	X	X	X	X	X	X	X	X	X	X
History											
Archival/retrieval capability according to user-defined criteria	X		X		X				X	X	X

[5] EMSL can only handle 10 concurrent users for portions of its application. In addition, some key functional areas such as workflow that were rated as being present, were weak enough that a more in-depth evaluation would have ruled it out of contention

Category/Application	DOE					GOTS				COTS	
	EMSL	FBS	FWP	MAPPS	PMTS	NSF	NIH	ED	STR	SofTech	PTC
Reporting Capability											
Ability to aggregate data at multiple levels	X	X		X	X				X	X	X
Ability to add user-defined reports		X		X	X				X	X	X
Database accessible to external report writers and other DOE applications	X	X		X	X		X		X	X	X
Systems Related Capability											
Unlimited number of concurrent users		X	X	X	X	X	X	X	X	X	X
Support access to LDAP, OLE DB and ODBC data sources	X			X	X		X		X		X
Web-based for all functionality	X	X	X		X	X	X	X	X		X
Version control of proposals and audit trail	X						X		X	X	X
Workflow											
E-mail interface for notification of execution, completion, and exception conditions	X						X				X
User creation of unlimited number of workflows	X				X				X	X	X
Online review capabilities for both serial and concurrent processes	X								X	X	X
% of Technical Capability	77	59	32	50	68	27	36	14	86	82	95

Note: % of technical capability is calculated by totaling the number of capabilities matched, those categories with an X, and dividing by the total number of capabilities (i.e., 22)

5.3 Demonstrations

5.3.1 Purpose and Key Questions

The purposes of this step are to:

- See the applications in action
- Ask the vendors further questions about the applications

The key questions to be answered by the demonstrations and Q&A sessions are:

- How robust and flexible are the technical capabilities?
- How easily can the application be extended to include new functionality?
- How well will the application fit into the DOE operating environment?

It is important that the application support easy addition of extra functionality since it is anticipated that any of the COTS applications will need customization to support ePME requirements, or to add new functionality as requirements are identified.

The last question is particularly important because it determines whether the selection of any of these packages will:

- Limit or predetermine the choices made for other ePME modules
- Limit the ability of ePME to be integrated with other DOE systems under development (i.e., I-MANAGE)
- Place ePME outside of the bounds of the likely enterprise architecture being put in place for the Department

5.3.2 Product Demonstration Results

Real-time demonstrations were conducted of the three products. Members of the CSC ePME Requirements and Technical Teams charged with developing and integrating ePME attended the product demonstrations and asked questions covering business and technical considerations and concerns. These staff members used their expertise to evaluate the general strengths and weaknesses of the products, and ensure that key questions were fully answered by the vendors during intense question-and-answer sessions.

SofTech and PDMLink demonstrated their products using web meeting technology. STR, a local firm, demonstrated their product at the CSC offices. Notes summarizing the findings are included in Appendix B.

At the end of the demonstration, CSC staff concluded that PDMLink was the only viable product. If PDMLink had not been part of the evaluation, the conclusion would have been that there were no viable existing alternatives and that Submodules 1.1 and 1.2 must be custom built.

Following the product demonstrations, the various Federal managers of the ePME project visited Federal sites that have implemented PDMLink. Following the site visits, the ePME Project and Deputy Project Managers sought and received approval from the Executive Steering Committee to proceed with a pilot to test the 60% “out of the box” functionality.

5.3.3 Rationale for the Conclusion

The demonstrations showed a vast difference in the products. PDMLink impressed the CSC staff far more than the other two products because of the maturity and robustness of its implementation of the technical capabilities evaluated in the previous step. PDMLink was much more flexible and adaptable than the other two candidates, and it was much less proprietary than the other products, thus increasing its ability to be integrated with other applications and technical environments.

Sections 5.3.3.1 and 5.3.32 address robustness and flexibility of two very important capabilities – web-based functionality and workflow -- that proved to be strong differentiators between products (in answer to the first key question for this step). Sections 5.3.3.3 and 5.3.3.4 provide answers to the last two key questions (ease of extension and fit with the DOE operating environment).

5.3.3.1 Web-based Functionality

The ePME system and workflow administrative functions are required to be decentralized, with each DOE location performing its own administration. Therefore, it is necessary that the administrative functions be web-based as well as the main processing functions. Additionally, the administrative functions need to have the capability of being segmented by organization.

Only PDMLink combined these two features: web-based functionality for the administrative functions such as establishing workflow, adding new users, and setting up security to control access at the user level and the ability to segment these by mechanisms such as groups and/or domains, especially in the areas of workflow. STR allowed web access to its system administrative functions. However, it only supported two types of global administrators: grantee (the main type for everything) and review administration. SofTech does not provide any web-based system and workflow administration; these functions are all client-server.

PDMLink was designed from the beginning as a totally web-based application. The other products started out as client-server applications, and then only the main processing was web-enabled. Web-enabling an application versus creating it initially as a web-based inhibits the web functionality in many ways.

5.3.3.2 Robust Workflow

a. PDMLink Workflow Capabilities

PDMLink has robust and flexible workflow capabilities that were easily set up with an intuitive graphical click-and-drop capability. This is critical, based on the ePME requirements. Another unique feature of PDMLink was the ability to link workflows into a workflow lifecycle. This feature is extremely important to the ePME requirements because proposals will go through a lab workflow, then a site office workflow, and finally a Headquarters workflow. PDMLink workflow capabilities include:

Standard workflows are easily established, can be changed for one-time exceptions by the user, and can be data-driven, role-driven, time-driven or static.

E-mail notices can be automatically generated at any stage in the review process to convey any information. (e.g., status e-mails can be sent to the originator, overdue notices to the reviewer's supervisor, tickler notices to the reviewer).

b. SofTech and STR Workflow Capabilities

Workflow implementation in the other two products was not nearly as flexible and there was no capability to send e-mail tickler notices or other notifications.

Establishing and changing workflow in the other two products was confined to administrators, and was not as easily established. It could not be driven by data such as the submitter's organization. (e.g., if the lab code on the template is Los Alamos, the Los Alamos workflow is initiated).

5.3.3.3 Ease of Adding Extra Functionality

PDMLink has been designed to accommodate customers doing their own customized implementations of the product. Creating many of the configurations is as easy as filling in the blank; and those that require programming changes are easy to integrate with the package code because PDMLink is totally developed in Java and according to J2EE standards.

The STR product was essentially a custom grants application that had been developed for another Government agency. Flexibility to make specific configuration changes to the application was limited to those capabilities allowed by Oracle Forms, such as what fields or tabs will display or what labels on existing fields will be. However, these changes were limited to the existing fields in the system and did not allow for making DOE -specific changes. Database changes, adding new fields and/or tables, major changes in database entry screens that are not covered buy parameters in existing fields and adding functionality that is not in system now must go through the vendor in order to be implemented. They control this through their licensing scheme.

SofTech allowed all labels and data entry screens to be configured through their form builder. However, in order to access this functionality, users are expected to make a one time purchase of a programmer's toolkit to enable them to make programming changes using HTML, C/C++ or Perl.

5.3.3.4 Standards-Based Development Strategy

PTC, STR, and SofTech product offerings were evaluated to determine how compliant they were with the Federal and DOE Enterprise Architectures and what capabilities they provided for interfacing with other ePME modules, DOE applications, and other Federal applications. The Federal Enterprise Architecture preferred for eGovernment applications is Java and J2EE, providing functionality that supports integration among Web applications.

PDMLink, the PTC application, was developed in conformance with the industry-accepted IT standards that underlie the Federal and DOE Enterprise Architectures. It is fully compliant with J2EE and provides the following capabilities and features.

- Works on multiple application servers
- Interfaces with multiple portals
- Supports a range of LDAP servers and can provide single sign-on
- Supports PKI
- Supports XML-based import/export

Customization can be accomplished through an extensive Java API; no toolkit or application is needed.

In addition, PDMLink has multiple capabilities that enable it to interface with external modules and systems.

- InfoEngine, a component of PDMLink, can expose ePME functionality in a web services model for other systems to pull across the Web
- Adapters to an integration broker can expose the necessary functionality, which may pull or push information and manage the dissemination of information across the enterprise
- Custom point-to-point interface can directly utilize functionality exposed by another application

These capabilities provide all the tools necessary to integrate with other modules and systems with reduced cost and time.

ProductCenter, the SofTech application, is not in conformance with industry-accepted IT standards in the Federal and DOE Enterprise Architectures. It was initially developed as a client-server application and does not use Java or Java Beans and is not J2EE compliant. It has the following characteristics and capabilities.

- Works with multiple application servers
- Does not interface with PKI
- Does not work with portals
- Does not have the capability for single sign-on

Customization can only be accomplished using its toolkit, which is a separate purchase.

In addition, ProductCenter has limited capabilities for interfacing with external modules and systems. It only offers its BatchLoader (a separate purchase) as its primary interface. It is a C/C++ application used for getting legacy data from ASCII delimited files into the system. It does not support XML. It does not provide the capability to build adapters used to get information from other systems. Any other interface to an external system must be built from the ground up.

eGrants Plus, the STR application, is in conformance with the Federal and DOE Enterprise Architectures. It is an Oracle web-based application, which uses Oracle Forms and reports, 9iAS application server, Oracle 8i database and Discover and is J2EE compliant. It has the following characteristics and capabilities:

- Works only with Oracle's application server and portal
- Does not interface with PKI
- Does not have the capability for single sign-on
- Provides an XML interface

Any customization of the software must go through the vendor.

Although the Java tools and technology provide the foundation for building adapters that are not available from Oracle, the licensing scheme and restrictions on the software dictate that all interfaces to the application must go through the vendor.

5.4 Step 4 – Validation of PTC as the Best Viable Solution

The purpose of this step was to consult with outside experts about PDMLink in order to validate the choice of PDMLink as the best viable solution.

Key questions to be answered were:

- In the opinion of outside experts, is PTC a good choice to satisfy ePME Submodules 1.1/1.2 requirements?
- Are there reasons not to use the PTC product?
- Is there another product that would be a better choice?

The validation of the PDMLink choice consisted of the following:

- Another demonstration of the product using some ePME requirements
- Consultation with outside PDMLink experts
- Consultation with PDMLink customers, including a visit to the LANL facility where PDMLink is deployed

PTC tailored the demonstration to accommodate ePME workflow storyboard requirements. CSC staff was impressed with how easily the requirements were implemented in PDMLink, and a decision was made to pursue further validation of the viability of the product.

CSC has a center-of-excellence consulting group for product life-cycle management. These consultants work with manufacturing firms to automate their product data handling by installing and implementing PLM COTS products. They work with PDMLink as well as other PLM products. They analyzed ePME requirements against

their knowledge and experience with PLM COTS and came to the following conclusions:

- PLM products offer a robust, superior level of support for ePME Submodules 1.1 and 1.2 requirements.
- PDMLink, with its robust workflow and document version control, is the best PLM choice for ePME requirements.

The ePME staff also consulted via conference call with the Gartner group PLM expert, who had just finished a draft paper on PDMLink. The following points were made by the consultant during the conference:

- PTC is currently one of the leading companies in the PLM arena. PTC has invested heavily in their product to achieve this stature. Their initial product offering, ProEngineer, is a CAD/CAM product. Their diversification into the PLM field resulted from their customers' need to store and manage changes made to engineering drawings and product information. They acquired PDMLink in 1997 by purchasing Computervision. Sales were high until 9/11; they, as well as their competitors, have been struggling since. New sales remain low, but high earnings in the maintenance area have made product-related revenue an enviable 75% of total revenue.
- Chief competitors of PDMLink include: MatrixOne, EDS TeamCenter, and IBM[6]. Oracle and SAP are also in the early stages of developing a PLM product, but they lag behind the others. The chief differentiators that make PDMLink a better choice are the workflow features and the fact that PDMLink has been developed totally in Java and has always been web-based. The other three top competitors started out as windows-based and client server and have been web-enabled. They are also more proprietary in nature.
- PDMLink's customer base includes many of the largest corporations in the country, such as Lockheed Martin, General Dynamics, John Deere, and NASA. Implementation of a PLM product in a manufacturing environment means organizational change. PLM products are still fairly new. For that reason and not due to difficulties with PLM products, implementations still remain in large pilots. However, PTC Windchill has already been widely tested in several different environments in these companies.

PDMLink was demonstrated to the ePME Federal project staff using the ePME storyboards. The ePME Federal staff was impressed with the demonstration and sought a site visit with PDMLink customers. The CSC ePME Project Manager or Deputy Project Manager and members of the ePME Federal project team made site visits to DOE Los Alamos National Laboratory and NASA Johnson Space Center in Houston, both current users of PDMLink. Both groups expressed satisfaction with both PDMLink and PTC as a vendor.

[6] All have relationships with CSC. See disclosure statement in section 3.2.4.

Based on these validation steps, as well as the previous filtering steps, the decision was made to proceed with a comparison of the costs, risks, and benefits of PTC Windchill against custom development of Submodules 1.1 and 1.2 of ePME.

No additional validation of the remaining two products was performed because it was clear that only PDMLink had the overall set of technical capabilities to compare against the custom-built alternative.

Additional validation of PDMLink is being done via release 1, which will be piloted to a subset of laboratory, field, and program offices. The release will test the 60% "out of the box" functionality in PDMLink that addresses the requirements for submodules 1.1 and 1.2. The Pilot was approved by the Executive Steering Committee in October 2003.

6 Phase 2 Comparison of PDMLink and Custom Development

6.1 Step 1- Cost Analysis

6.1.1 Assumptions

6.1.2 Approach

6.1.3 Findings

6.1.3.1 Sensitivity Analysis – PDMLink COTS Solution

6.1.3.2 Sensitivity Analysis – Custom-Built Solution

6.2 Step 2 – Benefits Analysis

The purpose of this analysis is to identify the benefits associated with each solution, assess the probability of a benefit being realized by a solution, and describe the factors that impact the probability. The summary of these benefits help determine the right alternative for the technical solution of ePME Submodules 1.1/1.2.

6.2.1 Assumptions

- ePME system (module 1) will be web-based and include document management and workflow functionality.
- Custom-built system includes DBMS, operating system (server and desktop), development framework(s) and language(s), custom programming.
- COTS system includes all components mentioned above plus PTC application code.

6.2.2 Approach

The following table was adopted for ratings used in the probability for each benefit (it is also used in the risk analysis).

Table 6-3. Probability Levels

Level	Probability	Description
1	Remote	20% or less that this will occur
2	Unlikely	Less than 50% that this will occur
3	Likely	Over 50% that this will occur
4	Highly Likely	At least 80% that this will occur

5	Near Certainty	Almost 100% certainty that this will occur

The following table lists the possible benefits of the custom and COTS (PTC PDMLink) solutions. Probabilities were individually assigned by CSC ePME project experts followed by a meeting to achieve consensus. The rationale for assigning the probability that the benefit will occur is explained in the rationale column. Circles indicate where a significant difference exists between the two approaches.

Table 6-4. Comparison of Benefits

Benefit	Probability		Rationale
Earlier deployment and use	**Custom**	1	• March 2004 deployment is same for custom and COTS for Release 1.
	COTS	4	• Workflow and document management functionality existing in PTC PDMLink allows for earlier deployment of a production system for DOE use (Release 2). (October 2004 versus January 2005 [Original custom date. At this point the date would be later]). • If the schedule changes, existing functionality already in PDMLink gives possibility of faster deployment to meet schedule changes. • Early deployment results in a cost savings o Savings in a few million dollars by allowing DOE to utilize electronic proposal submittal sooner (Note: Since the bulk of savings occurs during January to April timeframe, October deployment will not save a proportionate amount of money. o Savings in development time, allowing developers to advance to future modules sooner. • Less coding required to meet core functionality listed in requirements – developers can concentrate on configuration and design to meet business functionality.
Less risk of failure in building the system because of the functionality already built in PDMLink	**Custom**	2	• Entire application infrastructure (e.g., workflow, document management) must be built in addition to specific functionality for custom
	COTS	4	• Document management and workflow functionality already built-in PDMLink. • Infrastructure exists in PDMLink to support available functionality
Required functionality has been developed and refined in a more robust, flexible fashion	**Custom**	1	• Custom development focuses narrowly on requirement set at hand • Robustness and flexibility improves in later releases
	COTS	4	• PTC has spent many dollars and effort in developing, refining and testing their product. o Approximately 20 million dollars over approximately 3 years in conjunction with the Army spent in development and testing of the workflow component. o Over 32,000 customers, many in Federal arena; several years experience in PLM software. • Vendor has opportunity to utilize lessons learned in enhancing software.

Extensive testing of software to find and correct anomalies or "bugs".	**Custom**	2	• Much larger test effort from unit test on. • Much larger user testing requirement to approach COTS reliability.
	COTS	4	• Customer base results in large amount of usage, enabling users to find and report issues to company for resolution. • Less testing of code for core functionality used out of the box – testing can concentrate on configuration issues and changes to software to meet business functionality.
Upgrades will address keeping the application technologically current, thus prolonging its useful life span.	**Custom**	3	• Upgrades are timelier for custom – can be scheduled on an as needed basis. • Custom can use upgrades to be more responsive to outside pressures, such as changing architecture in DOE.
	COTS	3	• Developers can concentrate on just the technology upgrades not implemented by vendor for COTS.
Additional support resources (vendor) are available for troubleshooting and implementation	**Custom**	2	• No organized, domain-sensitive support structure.
	COTS	3	• Established customer support, discussion and user groups for PDMLink. • Installed customer base in Federal government for help in resolving issues. • Software in use for longer time than custom application creates a larger knowledgebase for resolution of issues.
The application can be built to exact user requirements and specifications.	**Custom**	4	• Custom can be designed and built to reflect all specific approved requirements. • PDMLink functionality may not meet all approved requirements. • If requirements change, custom may be more flexible in meeting the changed requirements.
	COTS	2	• Configuration and customization can be applied to meet most common requirements quickly.
Application can be enhanced and upgraded to ePME specifications	**Custom**	3	• Custom is more flexible in meeting specified requirements.
	COTS	2	• Customization may be required for PDMLink, may have to wait for upgrade to meet new requirements. • Assure a large embedded base and a mature customer base.
Ease of integration with other modules and interface with other applications	**Custom**	4	• Custom may be more easily changed to meet future needs. • Custom may have fewer Issues integrating with other products.
	COTS	3	• Supported integration points will provide quicker integration (e.g., configuration-level of effort).

General development expertise is easier to hire than COTS-specific expertise	**Custom**	4	• Developers are easier to find with knowledge in a broad base of development tools and methodologies.
	COTS	3	• Market for developers with specific knowledge of Windchill is smaller; cost for these developers may be more.

6.2.3 Conclusion

The COTS-based solution offers several important and distinct benefits over the custom solution:

- **Earlier schedule deployment –** Schedule estimates for both systems provide higher certainty that the COTS-based option can be deployed sooner than the custom approach. [7]
  Release 1 (pilot deployment) – Both COTS and Custom – March 2004
  Release 2 (full deployment) – COTS – October 2004; Custom – January 2005

Note: The custom release dates were based on design. Instead, the ePME Project Team sought and received approval from the Executive Steering Committee (ESC) in October to proceed with a pilot using PDMLink. Therefore, if the ESC decides in January to return to a custom solution, the custom releases will be delayed by 6 to 8 months.

- **Greater development reliability** – – PDMLink provides an estimated 60% out-of-the-box functionality when matched against the approved requirements. In the custom approach, all of the functionality would have to be developed and tested. Built-in functionality is more robust and more reliable, having been defined and tested over an extended period of time by a large number of users. This conveys the risk in a schedule constraint environment.
- **Proven vendor technical and support infrastructure** – The vendor will offer substantial technical support and deployment assistance to address technical issues that arise throughout the project. Existing government clients validate this conclusion.

6.3 Step 3 – Risk Analysis

The purpose of this analysis is to identify the technical risks associated with each solution, assess the probability, describe the mitigation factors and assess the impact on Schedule and Technical Performance. The result of this analysis is a factor in adopting the right alternative for the technical solution of ePME Submodules 1.1/1.2.

6.3.1 Assumptions

- ePME system (Module 1) will be web-based and includes document management and workflow functionality.
- Custom-built system includes DBMS, operating system (server and desktop), development framework(s) and language(s), custom programming.
- COTS system includes all components mentioned above plus PTC application code.

[7] A baseline CD-1 schedule for the COTS solution is under review.

6.3.2 Approach

CSC followed the methodology described in "ePME Risk Management Plan" and the "Risk Management Guide for DOD Acquisitions". The following tables were used for Rating and Prioritization.

Table 6-4. Risk Probability Table

Level	Probability	Schedule Impact	Technical Performance
1	Remote	Minimal	Minimal
2	Unlikely	Additional Resources required; able to meet dates	Acceptable with some reduction in margin
3	Likely	Minor slip in key milestones; not able to meet need date,	Acceptable with significant reduction in margin
4	Highly Likely	Major slip, key milestone or critical path impacted	Acceptable, no remaining margin
5	Near Certainly	Cannot achieve key milestone	Unacceptable

CSC applied the impact ratings for each impact category after mitigating the risks. The overall rating is achieved by multiplying the probability by impact. Table 6-5 depicts the overall risk rating for a typical IT project, and is aligned with the ePME risk prioritization chart.

Table 6-5. Risk Rating Table

Probability						
	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
Impact						

Ratings: Green = Low; Yellow = Medium; Red = High

Table 6-6 provides a comparison Risk Analysis between a COTS and custom software solution. CSC selected two impact areas to assess: Schedule and Technical Performance. Schedule impact was based on the pre-determined implementation date for Submodules 1.1/1.2 in Master Schedule version 1.1.1. Technical Performance impact was based on a combination of impacts to analysis, development, infrastructure and deployment phases that will determine the quality and performance of solution.

Probabilities and impacts were individually assigned by CSC ePME project experts, followed by a meeting to achieve consensus. Circles indicate where a significant difference exists between the two approaches.

Table 6-6. Risk Analysis: Custom vs. COTS Solutions[8]

Risk Factor		Prob.	Risk Mitigation Strategies	Schedule Impact	Tech Perf. Impact	Risk Rating for Schedule	Risk Rating for Tech Perf
Scope creep: requirements added late in development cycle.	**Custom**	4	• Manage Change to requirements by instituting and adhering to CM policies. • Utilize best in class PM methods. • Ensure requirements are signed off by stakeholders and user representatives.	3	2.0	12	8
	COTS	3		2	1.5	6	4.5
Unexpected technical challenges discovered.	**Custom**	3	• Perform early prototyping of key technical unknowns. • Implement a pilot. • Maintain access to key external technical experts.	3	2.0	9	6
	COTS	2		2	1.7	4	3
Difficulty in gaining business expert's time to provide the more detailed requirements required	**Custom**	2	• Allow enough time early on to identify and reserve key functional experts • High level management mandates time given to project by functional experts • Utilize additional functional expert resources that may be outside the scope of the project. • Model some functionality off other COTS products.	4	4.0	8	8
	COTS	2		3	3.0	6	6
Interfacing with external systems difficult	**Custom**	1	• Seek product with open standards architecture • Gain early knowledge of interfacing systems. • Find similar implementations and gain knowledge based on lessons learned.	2	1.8	2	2
	COTS	2		3	2.3	6	5
System upgrades difficult to implement	**Custom**	1	• Reduce/eliminate dependency on future features. • Seek product with customization preservation features. • Seek high requirements fit / minimize customization.	2	1.3	2	1
	COTS	2		3	1.7	6	3

[8] The Risk Ratings for Schedule and Technical Performance are the residual risk after applying the risk mitigation strategies.

Risk Factor		Prob.	Risk Mitigation Strategies	Schedule Impact	Tech Perf. Impact	Risk Rating for Schedule	Risk Rating for Tech Perf
Vendor financial stability	**Custom**	1	• Reduce/eliminate dependency on future features. • Obtain source code to software. • Assure a large embedded base and a mature customer base.	1	1.0	1	1
	COTS	2		2	1.5	4	3
High staff turnaround.	**Custom**	2	• Monitor and improve employee morale as necessary. • Utilize cross-training and establish backups for key areas of responsibility.	3	2.7	6	5
	COTS	1		4	3.3	4	3
Integration among system components and other modules difficult	**Custom**	2	• Seek product with open standards architecture • Find similar implementations and gain knowledge based on lessons learned.	3	1.5	6	3
	COTS	2		3	2.5	6	5
Delivered software misses key requirements	**Custom**	1	• Validate requirements early through interim releases and pilots. • Conduct thorough system and user acceptance testing. • Ensure requirements are signed off by stakeholders and user representatives	3	2.7	3	3
	COTS	1		3	2.7	3	3
Difficulty obtaining development staff with required expertise.	**Custom**	1	• Utilize contractor resources. • Utilize vendor professional services. • Recruit talent with product experience. • Obtain corporate resources with product experience (i.e., CSC consulting group).	2	1.5	2	2
	COTS	2		2	1.7	4	3
Functionality constraints found that may require modification, if possible	**Custom**	1	• Pilot the system to identify deficiencies. • Allow time in project plan to remediate issues found. • Select product that is easy to modify and customize. • Align business processes with product	2	1.5	2	2
	COTS	2		2	1.3	4	3

Risk Factor		Prob.	Risk Mitigation Strategies	Schedule Impact	Tech Perf. Impact	Risk Rating for Schedule	Risk Ratin Tech Per
Reliability of software unknown	**Custom**	2	• Seek examples of high usage implementation. • Check references of other users of software. • Test system thoroughly and pilot.	1	1.3	2	3
	COTS	1		1	1.3	1	1
Licensing and software procurement delays	**Custom**	1	• Establish close working relationship with vendor. • Obtain evaluation software sufficient for needs in early development.	1	1.0	2	2
	COTS	2		1	1.0	1	1
Incompatible with enterprise architecture	**Custom**	1	• Seek product with high compatibility with EA standards. • Establish migration plan to meet EA standards. • Obtain waiver from agency for application based on benefits.	1	1.0	1	1
	COTS	1		1	1.0	1	1

6.3.3 Findings

Each of the deployment options has risks that must be recognized and managed during the project. These risks affect both the cost and schedule estimates for the alternatives, as well as the potential that they could affect future technology decisions (both in integrating Submodules 1.1/1.2 with other ePME modules, and in integrating ePME with other DOE systems). The purpose of the risk evaluation was to identify the major risks, identify their magnitude (likelihood and impact), and identify risk mitigation strategies adequate to reduce the risk frequency and impact to manageable levels. The conclusion was that both alternatives have risks, all risks are manageable, and none are detrimental (in the "red" category).

The risks are split between showing a higher risk between the custom and COTS solutions. However, a major observation is that the ratings for risks where the custom solution is higher push the risk into the medium (yellow) range. Though there are risks where the COTS ratings are higher, the ratings themselves are still in the low (green) range. Therefore, the percentage of these risks affecting project is lower than those for the custom solution.

The risks are not independent of each other. Items which make higher scores for one solution under a specific risk create different scores under a different risk. The same factors that help to make the custom solution a higher risk under scope creep help to make it a lower risk for integration with external systems. Decisions regarding custom versus COTS solutions need to factor these interdependencies into account

This section gives more insight and clarification as to why circled areas in the Risk Analysis table have a wide discrepancy in the ratings. Theses areas were selected for a combination of two reasons:

- The risk ratings between custom and COTS had different levels of risk (low vs. medium) and/or
- The discrepancy between the ratings was 3 or greater at the same risk level.

6.3.4 Comments on Risk - Scope Creep

Risk: Scope creep: requirements added late in development cycle.

Custom Risk Level Schedule:	Medium	**Risk Rating Schedule:**	12
COTS Risk Level Schedule:	Medium	**Risk Rating Schedule:**	8
Custom Risk Level Tech Perf:	Medium	**Risk Rating Tech Perf:**	8
COTS Risk Level Tech Perf:	Low	**Risk Rating Tech Perf:**	6

The ratings for this risk push the risk for custom into a higher risk rating. Any time the requirements change late in the process, the potential for a large impact on schedule and/or already implemented technical solutions increases. It creates a moving target which rewrites the rules used to meet the goals decided upon earlier in

the project. The primary consideration here is why the impact would be greater for a custom build. The answer to this is twofold:

1. The chance of scope creep happening in a custom solution is greater. Custom solutions are viewed by system users as more flexible; they expect that the software will tailored to their specific business needs. This promotes the attitude that changes can be implemented regardless of the stage of development because since "we are building, it we can do what we want". Unfortunately, this does not take into account the possible "unraveling" of a system which may need to take place to accommodate these changes and the time it takes to do this. This is analogous to someone knitting a sweater and then being asked to insert a design in a section already completed.
2. The same factors that promote the changes in requirements late in the process serve to restrict this tendency in using a COTS product. Where the thought on a custom solution is "we are building it, so we can make it do what we want", the thought on a COTS product is "this is what the product does, so we have to accept it and find a way to work with it". This does not preclude changes that must be made to address business processes. However, the tendency of users is to accept the more restricted parameters that a COTS product may have. To use the sweater example from above, this is acceptance of not being able to insert the design into a completed section because the knitter only has specific colors of yarn to work with.

6.3.5 Comments on Risk – Unexpected Technical Challenges Discovered

Risk: Unexpected technical challenges discovered.

Custom Risk Level Schedule:	Medium	**Risk Rating Schedule**:	9
COTS Risk Level Schedule:	Low	**Risk Rating Schedule**:	4
Custom Risk Level Tech Perf:	Low	**Risk Rating Tech Perf**:	6
COTS Risk Level Tech Perf:	Low	**Risk Rating Tech Perf**:	3

Unexpected technical challenges will always occur when developing a system. This is true regardless of which solution, custom or COTS, is used. The impacts for this risk become a factor of the infrastructure and support mechanisms available to mitigate the risk. Two factors that affect this impact are:

1. When using a COTS product, the support mechanism for resolving technical challenges is already established. There is usually a large knowledgebase of experience to draw on from others who have used the product or from the vendor directly.
2. Though the pool of knowledge for tools being used to develop a custom application exists, there is the distinct possibility that a developer will need longer to find a solution to a problem. There may be multiple sources needed to find an

answer and each of those sources will have to be analyzed to determine if they are relevant to the problem. As a result, the impact is greater on the schedule than it is on technical issues.

6.3.6 Comments on Risk – Business Expert's Time Availability

Risk: Difficulty in gaining business expert's time to provide the more detailed requirements required.

Custom Risk Level Schedule:	Medium	**Risk Rating Schedule:**	8
COTS Risk Level Schedule:	Medium	**Risk Rating Schedule:**	8
Custom Risk Level Tech Perf:	Low	**Risk Rating Tech Perf**:	6
COTS Risk Level Tech Perf:	Low	**Risk Rating Tech Perf**:	6

When analysts and developers do not have access to functional experts to explain business processes, a project can be placed in jeopardy. This is reflected in the same ratings for both schedule and technical performance. The main difference between the custom and COTS solutions is the level of effort needed to create some functionality in the application.

For a custom solution, the developer has to create everything from scratch. If there is no information on what to create, it is very difficult to create anything that is worthwhile. The information must be extrapolated from whatever knowledge the developer has of the business.

The same does not hold true for the COTS solution. There is already functionality built into the software. Therefore, a user is assured of the software performing some processes. Without the knowledge from the business expert, the issue becomes the tailoring of the available functionality to more specifically handle the business needs of the user.

6.3.7 Comments on Risk – Interfacing with External Systems

Risk: Interfacing with external systems difficult.

Custom Risk Level Schedule:	Low	**Risk Rating Schedule:**	2
COTS Risk Level Schedule:	Low	**Risk Rating Schedule:**	6
Custom Risk Level Tech Perf:	Low	**Risk Rating Tech Perf:**	2
COTS Risk Level Tech Perf:	Low	**Risk Rating Tech Perf:**	5

Successful COTS vendors utilize open standards and expose methodologies to the developer to enable them to interface the software to other systems in their organization. However, like system upgrades, changes to the software can have an affect on what was done to interface with other systems. Additionally, this risk is two sided, that is, it becomes a factor when there are changes to the application software

or to the outside systems the application is interfacing with. Generally, COTS solutions are higher risk to deal with in this area because of the restrictions of the software.

In a custom solution, the flexibility of the process and use of tools allows the developer to more easily react to the changes needed to interface with external systems when changes are made. In a COTS solution, the developer is limited to the access points allowed through APIs (Application Programming Interfaces) or the functionality the software allows for interfacing with data outside of the system.

The COTS software database may also have limitations which restrict the developer. All of these factors help to contribute to higher probability for this risk using COTS software.

With respect to the interface between ePME and I-Manage, PTC provides a number of methods for interfacing with external modules and systems (see section 5.3.3.4). At this time it is expected that XML interfaces will be implemented in Module 3 for data exchange between ePME and I-Manage. Since both applications are in compliance with the DOE Enterprise Architecture and support XML, there is low risk that irresolvable problems will occur.

6.3.8 Comments on Risk – Implementing System Upgrades

Risk: System upgrades difficult to implement.

Custom Risk Level Schedule:	Low	**Risk Rating Schedule:**	2
COTS Risk Level Schedule:	Low	**Risk Rating Schedule:**	6

The restrictiveness of a COTS product can contribute to a schedule impact under this risk.

Vendors attempt to make their products backwards compatible to allow the existing user base to leverage their current software installations. However, there is always the risk that something developed earlier to tailor the software will not work under the new upgrade. This is true not only for customizations but also for configurations. It needs to be noted that the greater impact is in the schedule area and not the technical performance area. There are technical resources for finding solutions to issues arising from COTS software upgrades but the implementation of those solutions may take longer due to the parameters within which the developer must work.

6.3.9 Comments on Risk – Vendor Financial Stability

Risk: Vendor financial stability

Custom Risk Level Schedule:	Low	**Risk Rating Schedule:**	1
COTS Risk Level Schedule:	Low	**Risk Rating Schedule:**	4

This risk is more appropriate to usage of a COTS product. It should be noted that despite the discrepancy between the ratings for the custom and COTS solutions, the rating of the risk is low for each one. Two factors make the risk of impacting the schedule higher for COTS:

1. The first factor is that the developer is basing the solution all in one area; i.e., “placing all his eggs in one basket”. This is true for the procurement of the software in addition to the performance. If the vendor cannot deliver at anytime during the project, the development process can be slowed or stopped, which impacts the schedule.
2. The opposite holds true for a custom solution under this risk. There are a myriad of development tools to use and many vendors from whom to procure them. Though on the surface this would seem to imply an impact to the schedule because of more possibilities, it actually ends up facilitating the process by eliminating roadblocks encountered during procurement and development.

7 Conclusion

Using the PDMLink product as the solution for Submodules 1.1/1.2 will accelerate ePME time-to-value. It brings greater likelihood of earlier deployment and robust functionality for DOE. It accomplishes this objective for a somewhat lower cost and with less risk than the custom solution.

Earlier deployment for Submodules 1.1 and 1.2 is a major DOE management objective. Using PDMLink, Release 2 can be deployed in October 2004, well in advance of the peak workflow period that starts in late January. This provides sufficient time to ensure that all personnel are trained and familiar with the system and the new business process, and that any problems have been identified and resolved.

There is less risk of slipping this scheduled date with PDMLink than with the custom solution (the scheduled date of which is January 2005[9]). The CD-1 delivery date for Release 2 for the COTS solution is October 2004. A risk mitigation strategy can be implemented at CD-2 to reduce the scope of Release 2 without compromising core functionality, in the event it is necessary to do so to avoid schedule slippage. On the other hand, if it is determined at CD-2 that the estimated delivery date for the custom solution (January 2005) needs to slip, it will be much harder to reduce the scope as a risk mitigation strategy to avoid the slippage. This is because much of the core functionality with the custom solution needs to be built and integrated from the ground-up (as opposed to being available out-of-the-box as with PDMLink). This functionality cannot be removed in the event of schedule slippage.

PDMLink has been developed over a longer period of time (5 years) with a much larger budget (billions of dollars) and has been tested and modified with a very large user base that includes major industry clients, NASA, and DOE laboratories. As a result, there is higher likelihood that most of the problems that will need to be ironed out will be with respect to the new business processes, not system problems.

It should be noted that the October 2004 date for going production with Submodules 1.1 and 1.2 and PDMLink is premised upon two important assumptions:

1. Resources identified as necessary in the new COTS master schedule to complete Submodules 1.1 and 1.2 are available in the DOE FY2004 budget.
2. There are no procurement delays in obtaining PDMLink.

Therefore, CSC recommends that DOE proceed with Release 1 using PDMLink and following its successful demonstration, continue with PDMLink for Release 2.

[9] See earlier discussion concerning the fact that this date is no longer realistic for a custom solution

Appendix A. Applications Identified in Step 1

Information about applications that was used to rule them in or out was gathered in several ways:

- Information about DOE applications was gathered in workshops and in data gathering for the CME Business Case
- Information about other Government agency applications was gathered from application documentation available on websites and from project staff
- Information about COTS grant proposal systems was gathered on websites
- Information about COTS PLM products was gathered from a Gartner group article and from vendor websites.

Summary tables that evaluate the identified applications and their disposition as candidates follow.

A.1 DOE Applications (17)

System Name	Location	Disposition and Reason
EMSL User Proposal System	Pacific Northwest National Laboratory EMSL User Facility	Proposal system for use of the facility for high performance computing, provides appropriate functionality, kept for further consideration
eWFO Database	Lawrence Livermore National Laboratory (LLNL) Budget Office	In development, proprietary system not suitable for enterprise-wide implementation
Field Budget System (FBS)	LLNL	Used for same purpose as Submodules 1.1 and 1.2, kept for further consideration
Financial Control Distribution System (FCDS)	Nevada Nuclear Nonproliferation and Security Administration (NNSA) Service Center	A budget execution system, not a proposal submission and review system, may be considered for Module 3
Funds Control and Distribution System	NNSA Albuquerque Service Center	A budget execution system, not a proposal submission and review system; may be considered for Module 3
Field Work Proposal (FWP) tool	Sandia National Laboratory	Used for same purpose as Submodules 1.1 and 1.2, kept for further consideration
Laboratory Directed Research and Development (LDRD) Database	LLNL LDRD Program Office	Too specialized, not broad enough functionality for non-LDRD proposals
LDRD Database and Production System	Sandia National Laboratories LDRD Program Office	Too specialized, not broad enough functionality for non-LDRD proposals
LDRD/PDRD System (Laboratory & Plant Directed R&D)	Headquarters Chief Financial Officer	Too specialized, not broad enough functionality for non-LDRD proposals

System Name	Location	Disposition and Reason
Management and Proposal Preparation Submission (MAPPS)	Argonne National Laboratory	Used for same purpose as Submodules 1.1 and 1.2, kept for further consideration
People Soft Budget Module	Brookhaven National Laboratory	Budget formulation system, not enough proposal submission functionality
Program Management Tracking System (PMTS)	Lawrence Berkeley National Laboratory	Used for same purpose as Submodules 1.1 and 1.2, kept for further consideration
Project Management Control System (PMCS)	Stanford Linear Acceleration Center	Financial information only, not enough proposal submission functionality,
Project Management Information System (ProMIS)	National Energy Technology Laboratory	Project tracking system, not a proposal submission and review system
Universal Budget Estimating Tool (UBET)	Los Alamos National Laboratory	Financial information only, not enough proposal submission functionality
Great Plains eEnterprise	Princeton Plasma Physics Laboratory	Financial information only, not enough proposal submission functionality
Web based (client server) Proposal pricing system	Pacific Northwest National Laboratory	Pricing only, not enough proposal submission functionality

A.2 Existing Government Applications at Other Agencies (6)

The search for GOTS applications found several GOTS packages for creating proposals, but all of the applications were geared towards submission of grant proposals by external entities. Only one, e-Grants Plus, displayed the capabilities for internal review and response that is needed when working with the DOE national laboratories. However, because the first three applications discussed below were well-known possible candidates, it was decided in this initial screening process to retain these applications to demonstrate how they compared to the existing DOE and COTS applications being considered.

Application Name	Government Agency	Description	Disposition
eApplication (formerly eGAPS)	Department of Education	Grant application system	Kept, to compare with DOE and COTS applications but not considered a good candidate
FastLane	National Science Foundation	Grant application and award system	Kept, to compare with DOE and COTS applications but not considered a good candidate

Application Name	Government Agency	Description	Disposition
NIH Commons	National Institutes of Health	Application suite that includes grant applications, status system, e-mail notices of awards	Kept, to compare with DOE and COTS applications, but not considered a good candidate
STR's eGrants Plus	Corporation for National and Community Service	Grants application, review and award system	Kept, recommended by Oracle, has appropriate functionality
Grant Information System (GIS)	Department of Transportation (DOT)	Answers questions about assistance awards, such as awards to various states and counties; provide periodic reports on various aspects of assistance programs; and provide periodic reporting to the Federal Assistance Awards Data System (FAADS)	Not considered further, does not support the proposal submission and review process
AdminWeb	Office of Naval Research (ONR)	Tracks the status of awards as well as monitors close-out documentation and NFE submissions for awards managed by ONR	Not considered further, not a proposal submission application

A.3 COTS Applications (16)

A.3.1 Proposal Submission Packages (5)

The following grants submission products exhibited one or more problematic characteristics as explained in the body of the document and therefore did not pass Step 1:

Product	Company
OneQuot	Amplify Software
ProposalMaster	Sant Corporation
ProposalDx	SitewareDx
ProposalKit	CyberSea
e-Proposals	Pragmatic Software

A.3.2 Product Life-Cycle Management Packages (11)

The following table presents the 11 PDM/PLM applications that were considered:

Product	Research Notes	Disposition
PTC Windchill	One of top offerings, robustness of workflow, ability to assimilate various data types	Kept for further evaluation
SofTech	Although smaller company has all the functionality of PLM	Kept for further evaluation
Dassault Systems (IBM)	Has V5 architecture, CATIA V5 design software	Eliminated, uses db2
EDS PLM	Absorbing SDRC and UGS applications, transition not complete before 04	Eliminated too product-to-market oriented
MatrixOne	Customers validated benefits and rapid deployment (<6 months) financial problems, doing cost cutting	Eliminated, not flexible enough
Agile	High-technology, healthcare, and automotive markets, applications address design, sourcing, management of product life cycle costs, program management	Eliminated, too product-to-market oriented
Formation Systems	Only vendor for process industries, emphasizes product development, partnered with MatrixOne, MatrixOne customers with formula-intensive R&D should consider Optiva product	Eliminated, too product oriented
Oracle	Vision encompasses product, resource management, financial tracking, Oracle customers should use status as early adopters to negotiate fees	Replaced at Oracle's recommendation with STR
SAP	Works best for enterprises that design less sophisticated products	Eliminated, DOE already dealing with two ERP vendors
Invensys/Baan	Best suits established Baan customers, foreign owned company	Eliminated, Foreign company, for Baan customers

Product	Research Notes	Disposition
Centric Software	Greatest success at supporting small groups of designers	Eliminated, for small installations

Appendix B. Step 3–Pros and Cons of Products

Product demonstrations were held in Step 3 for the three products that scored highest in Step 2. The following sections provide information gathered on each product during its demonstration. Some general questions and areas for discussion were established for the demos as presented in B.1. However, each of the CSC experts also addressed their own questions and concerns.

B.1 Questions for Product Demos

Oracle RDBMS – what version(s) used

Budget component

Email interface

Scalability

Cost of ownership – how do they compute that

Configurable – what can be changed – labels ? data screens ? are there limits?

Electronic signature – how implemented – only userid & password ?

Application Server Architecture

J2EE Compliance

Portal – theirs/others

Reporting

Single Sign on

Audit trail/how granular for changes

Searching – attributes/text search

Security
Groups/group roles/individual access – is that by user or the 'product'; if by product can the reverse be implemented

How is access determined…can it be keyed off of data field values

Administration

Web or client server

Can there be levels of system administrators

Can other items be added, such as other statuses or other reference tables?

Facility for getting data from other systems

API/Toolkit for additions, customization

Workflow

Are the workflows by role or individual/ can they be assigned at run time

Can a workflow be data driven

Are they visible to everyone or can they be limited by groups or individuals

Mass copy functionality – sending multiple projects to the next person or signing multiple projects

Costing

Quote per seat – what does this include, what are the limitations

Are the modules sold separately or as packages

Do you have site licensing or discounting

What components are sold separately, what in packages (costs)

Government contacts

FDA

Other

Hands-on

Is either user documentation or hands on software available for evaluation?

B.2 STR

STR, the **L.L.C.** eGrants Plus application, is installed at the Corporation for National and Community Service (CNCS) and the Inter-American Foundation (IAF). There is a one-time license fee of $250K. Installation and configuration for the first organization is $100K. Each subsequent organization is $5K-$30K. The yearly maintenance fee is 30% of the license fee.

eGrants Plus is an application that is written specifically for processing grants through the regulated lifecycle in Federal agencies. It tends to be ahead of the curve in this area, partly by its extensive functionality and partly by positioning itself as a COTS product ready to accept grant applications from the Federal Storefront. During the first year of installation at CNCS, the system processed 1700 grants, registered 6000 users and supported up to 500 concurrent users. At least one third of the system is devoted to merit and peer review, and CNCS has had up to 30 review panels meeting at one time in the system.

Though it interfaces with other financial systems at its installations (STR is in talks with Oracle to interface with Oracle Financials), each interface at an installation must be customized. There are plans to upgrade the software to Oracle 9i with the next few months and the vendor believes that this will add some the functionality that is missing from the system now, such as the ability to handle attachments.

Despite its functionality, the product is still limited in comparison for what is needed in ePME. There is not enough flexibility to transform the system from being very grant-centric to one that will handle the complexities of the lab submission process for work and budget calls.

The advantages of eGrants Plus are as follows:

- Very structured, interconnected application; handles full life-cycle of grants from inception to closure, including subgrants
- All functionality is web-based, including administration; outside users can check on their status of their applications
- Dynamic Configuration–administrators can configure system to display different tabs and fields on tabs dependent on program or organization
- Merit/peer review module
    - Robust, captures personal and educational information on reviewers
    - Allows for review comments and scoring; can aggregate scoring for consensus
- Budget and financial fields
    - Has totaling functionality

    - Ability to associated rules with budget lines; system will not allow proposal to be sent to next step until budget is valid and meets rules
- Roles
    - Unlimited ability to create roles and assign parameters to them
    - Users can perform multiple roles
- Audit trail for workflow and transactions; captures data for site visits
- Versioning of transactions and data
- Sends email notifications so next user in workflow can take action
- Has facility for XML data exchange
- Flexible canned and ad hoc reporting based on Oracle Discoverer; reports are saved as .pdf files.
- 508 compliant
- Uses current technology: Oracle 8i database, Oracle Forms and Reports, 9iAS Application Server

The disadvantages of eGrants Plus are as follows:

- Specifically geared towards structured grants process; this limits flexibility
- Does not handle document attachments; functionality will not be in the system until it is upgraded to Oracle 9i using the Oracle Internet File System
- Workflow
    - Must be preset by a grants administrator
    - Data driven only in regards to transactions; cannot be changed on as needed basis by a user
    - No capability for parallel workflow
    - No ability to send multiple proposals through workflow–proposals must be sent one at a time
- Electronic Signature
    - Based on users having an account in the system and carrying the password through from the initial logon
    - No PKI capability
    - No bulk signature capability
- Though system has email notification, it cannot set up ‘ticklers’, i.e., send emails back to users to notify them that actions have not been performed
- Budget – Only handles one budget year, does not allow for out years
- Changes to database necessitate customization; changes are requested to be channeled through the vendor

- Though the system allows for two types of system administrators: grantee (whole system) and review (review module), it does not have the facility for local administrators for each organization
- No single sign-on
- Interfacing with other systems can only be accomplished through customization
- Only works with Oracle products; cannot utilize other application servers or tools for customization.

B.3 ProductCenter

SofTech's ProductCenter is installed at NASA Glenn Research Center and Goodrich Corporation. The application costs approximately $5K per concurrent user. This includes all core functionality and document server. The breakdown is as follows: Windows and Web client with all functionality except for Workflow is approximately $4200 per seat with Workflow approximately $750 per seat. Additionally there is a one-time production launch fee of $2500. Toolkit is sold for a one-time fee of $15K, but may then be used by any number of individuals.

ProductCenter is a product data management (PDM) product that became a SofTech product when the company acquired the Workgroup Technology Corporation (WTC). Though they are a smaller company than some of their competitors in the field, the product provides all the standard functionality expected from a product in this genre: document management, configuration control, change management and enterprise integration.

However, one of the main issues is their approach toward administering and customizing the software. Though the main system is web-based, the capability to both administer the system and use the graphical portion of the workflow is only available through a Windows client. This presents difficulties when trying to distribute the system across disparate locations. Although there are plans to change this in a future release, there is no firm date. Similarly, the graphical portion of the workflow is essential in the envisioning and creation of workflows. Additionally, they do not follow industry trends for customizing the system. Though the software is not behind technologically, it does not use the normal standards of Java, Java Beans and J2EE.

Despite its functionality, there are four main issues with the product: lack of web-based administration, lack of a web-based graphical interface for workflow, no Java-based ability to customize system, and the size of the company. Lack of web-based administration creates difficulty in implementing the software both in terms of cost and effectiveness. Lack of a web-based graphical interface for workflow creates difficulties for both distribution and ease of use. No Java based ability to customize system means a departure from the standard methodology of web-based development. Lastly, the concern over the size of the company is their stability. Will they continue to have enough resources to support the product and will they be around for the long term?

One or two of these would be challenging to implementing the software but all of these together make this not the optimum choice at the present time for ePME.

The advantages of ProductCenter are:

- All labels and screens are configurable through the form builder
- Access can be set by groups, roles and/or individuals
- Two levels of system administration:
    - Superuser–has control over all administrative functions
    - DBA user–Has limited administrative access; can add users
- Workflow
    - Ability to be set up through a client graphical interface
    - Can be determined by role, group or individual; user may select an individual performing a role at runtime
    - Supports sending of multiple proposals to next person in workflow
    - Can be data driven; that is, based on information contained on a data entry form
    - May be either form or route based; supports serial and parallel workflow
    - Has email notification, messages are customizable Electronic Signature
    - Can be attached to any number of functions in the system
    - Based on user id and password; compliant with FDA Federal Regulation Rule 21 CFR Part 11
    - Allow for approvals of multiple proposals
- Database items, such as reference tables and items used for drop down lists are configurable through the system interface
- Document Management
    - Stores document attachments in a fully secure vault
    - Maintains metadata on the documents for linking to the proposal/project
    - Revision control and file-based security
- Roles
    - Unlimited ability to create roles and assign parameters to them
    - Users can perform multiple roles
- Audit trail for workflow and transactions
- Integrates with other COTS products such as Microsoft Office, allowing users to have check in/check out capability.
- Sends email notifications so that the next user in the workflow can take action

- Versioning of data allows complete versions of a project to be maintained and locked to prevent further updates
- Flexible reporting interface allows users to create their own ad hoc reports without understanding the underlying database schema.
- Data can be viewed in native file mode or converted using ProductCenter GenView into universal viewing formats, such as Adobe PDF, for wider dissemination without the need for proprietary viewing tools.
- Works with multiple application servers: validated with Sun One Application Server (iPlanet), Microsoft IIS and Apache.

The disadvantages of Productcenter are:

- System administration functionality is not web-based, and is only available through the Windows client
- Workflow
  - Graphical interface only available through the Windows client
  - Workflows are visible to all users; Access to functionality of a workflow must be limited by security features
  - Not part of main application–must be bought separately
- Electronic Signature
  - Based on users having an account in the system and carrying the password through from the initial logon
  - No PKI capability
- Though the system has email notification, it cannot set up *ticklers*; i.e., send emails back to users to notify them that actions have not been performed
- Budget–allows for fields but must either use a customized interface or triggers in the database for totaling
- Does not use Java, JavaBeans and does not adhere to the J2EE standard.
- No single sign-on or ability to work with portals
- Must have a toolkit for customization; the toolkit does not use Java nor is compliant with J2EE standard
- The Batchloader application can be used extracting data from legacy applications to import into ProductCenter, but it does not support XML. It must also be bought as a separate product. This software would not negate the need to customize the import for ePME.

B.4 PDMLink

PTC's PDMLink is installed at Lockheed Martin, NASA, and U.S. Army. PTC is considered one of the top offerings in the PLM field, according to a Gartner group

study ("PLM Market Requires Best-of-Breed and ERP Capabilities", March 20, 2003). The vendor has focused its development efforts on collaboration supporting heterogeneous data and product data management (PDM) to support the business processes of project management. The robustness of the workflow component with the various ways of accomplishing tasks and the ability to assimilate numerous types of data testifies to this fact.

PDMLink works well to provide the functionality needed for ePME. Workflow and searching capabilities were more than adequate but reporting was not user intuitive. Additionally, changes to the database were more restricted; all changes having to be implemented through Rational Rose and UML. There is no in-built budget component, which means that one would have to be programmed for implementation. However, this functionality in this section is basic and should not be difficult.

Despite lacking in some areas; such as reporting and budget, the software more than meets the criteria in other areas, such as workflow and searching text. Its support for single sign on and interfacing with portals and various application servers should give it the flexibility needed to fit in with most environments. The apparent lack of flexibility in changing the database can also be viewed as a strength, allowing for more controlled and documented changes to the database structure. The total amount and complexity of functionality that the software brings to bear outweighs any deficiencies it may have, making it an option that warrants further investigation. The main question will be if the cost the vendor places on this functionality will outweigh the cost savings that the software provides.

The advantages of PDMLink are:

- Completely web-based data entry, administration, and workflow
- Data screens are set up as documents that can be created as needed
- Access can be set by groups, roles and/or individuals; allows for different levels of granularity
- Supports single sign on and will work with most portals
- Provides audit trail for transactions and workflow; appears to have multiple levels of detail available
- Workflow – Advanced workflow definition capabilities to automate proprietary processes, including support for nested processes, process referencing, conditional branching, voting, synchronization, timers, iterative loops, and response-based routing
    - Very robust and flexible; myriad of ways workflow can be designed and parameterized
    - Ability to be set up through a graphical interface, allowing user to readily see workflows as they are being designed

  - Can be determined by role, group, or individual; user may select an individual performing a role at runtime
  - May add/delete users in a workflow for a proposal during runtime. Change to proposal workflow will only affect that proposal/instance, will not change the template being used.
  - Can be data driven; i.e., based on information contained on a data entry form
  - Supports serial and parallel workflow; parallel workflow can be set to keep proposal from progressing until all users in parallel sections have finished their processing.
  - The system can be configured to add text for instructions/comments when an action is taken in the workflow, such as a rejection
  - Each lab, site office, and headquarters organization can have their own workflows, keeping them visible only to themselves. This is accomplished by the methodology determining how the workflows are stored.
  - Deadlines with escalation policies for proactive and follow-up notifications
- Lifecycle functionality–allows user to string processes together to make a complete lifecycle for a proposal. This functionality would allow labs, site offices and headquarters organizations to be included in a lifecycle, each having their own workflows with gates in between them.
- Capability for task reassignment
- Email
  - Allows email notification for users in workflow, in either direction notification
  - Messages are customizable
  - Supports LDAP so users can be added through email addresses; when the user attempts to logon, they will be asked to register
- Electronic Signature
  - Primarily based on user id and password
  - Can accept outside security, such as PKI, on web servers
- Allows for approvals of multiple proposals through workflow functionality
- System allows for versioning and iterations of documents
- Flexible in setup; can be configured in many different ways
- Able to have many layers of system administrators – may be as granular as needed
- All database changes must be implemented through Rational Rose and UML; This provides structure and documents the changes

- Customization
  - No toolkit or application needed for customization
  - Customization can be accomplished through an extensive Java API, which is heavily documented; J2EE-compliant
  - Documentation for API is provided with the software
- Provides capability of getting data from other systems (such as BARC) through proxy objects. Proxy objects are pointers in the PTC database that reference or allow access to items in other systems.
- Inbuilt robust text search searches all attributes and attachments
- Security
  - Check in/check out functions
  - Complete change history
  - Access control rules for individual documents and folders
- Folders and documents can be stored in a flat file structure or a hierarchy
- Runs on Oracle 8i; will support Oracle 9i. The database is accessible
- Works with multiple application servers, including support for SunOne Application Server, IBM WebSphere and open source Apache/ Tomcat/ JBoss.
- XML-based import/export of project information
- Through subscriptions and notification, allows a user to receive automatic notification of an event, such as a revision to a proposal or a change in status.
- Has viewing capability for numerous types of documents, regardless of software used to them.

The disadvantages of PDMLink are:

- All database changes must be implemented through Rational Rose and UML; this reduces flexibility in making changes and needs knowledge in the tool.
- Any interface for obtaining data from outside systems, such as lab systems, will have to be built
- No specific budget component; would have to be built using Java

Appendix C. Estimated Number of ePME Users Background Material

PTC license costs are based on numbers of named users. The first task is to estimate the potential number of users of ePME Submodules 1.1/1.2. This was done using two tables of information, as follows:

- Table C-1 ePME Users Estimate – Estimate of number of users per location done by the ePME CSC Project Manager and a DOE-knowledgeable member of the ePME Federal project staff. The information in Table 2 was used as the basis for the identification and grouping of labs and the identification of sites and program offices. An estimate of 1800 named users, 720 heavy users, and 1080 light users was derived.[10]
- Table C-2 Labs and Site Offices by Organization – List of labs and site offices by Program Secretarial Office (PSO). This table also provides the budget for each lab, the percentage of program lab budget for each lab, and whether they currently have an automated system. There are six program offices, 10 site offices, and 27 laboratories. Information in this table was gathered during the requirements definition effort. It was used as background material to define numbers of users for Table C-1.

[10] Since ePME's peak volume for receipt and review of proposals occurs within a 3-month window, it is expected that nearly all of the 1800 named users will be accessing ePME during that timeframe. However, the majority of the users will be processing quick transaction, such as reviewing and approving proposals. A pessimistic case of 50-75% concurrent users during the highest volume period yields an estimate of 900-1200 concurrent users. The PDMLink sizing guide provides sizing guidance for the Sun servers on which ePME will run. According to the guide, ePME will be able to support 1,200 users on its current platform. Further, the PDMLink architecture can scale to 10,000 or more concurrent users through adding processors to the current server or adding more servers.

Table C-1. ePME Users Estimate

	Number	Total Licenses per Loc	Heavy Users per Loc	Total # Heavy Users	Light Users per Loc	Total # Light Users	Total # Users
Labs with automated systems							
(NREL, PNNL,SNL, LANL, ANG, LLNL, LBNL, plus 5 others not specified…)	12	50	40	480	10	120	600
Labs without Systems							
(TJNL, BNL, Fermi, SLAC, PPPL, plus 7 others)	12	20	20	240	5	60	300
Field Offices	10	30			30	300	300
HQ PSOs							600
SC		150			150	150	
EE		100			100	100	
FE		75			75	75	
NE		75			75	75	
EM		0			0	0	
NNSA		200			200	200	
TOTALS				720		1080	1800

Table C-2. Labs and Site Offices by Organization

DOE PSO	Field Office	Labs	Lab Bud	% of total	Lab System?
SC	Chicago	Ames Lab	19.5	0.20%	no
	Oak Ridge	Argonne NL (East)	301	3.40%	MAPPS
	Berkeley	Brookhaven NL	346.7	3.90%	partially–PeopleSoft Budget
	Stanford	Fermi Nat'l Accelerator Lab	316.3	3.60%	no
		Lawrence Berkley NL	292	3.30%	PMTS (Program Management Tracking System)
		Oak Ridge Institute	10.2	0.10%	
		Oak Ridge NL	751.2	8.50%	think so
		Pacific Northwest NL	288.7	3.30%	EMSL
		Princeton Plasma Physics Lab	66.4	0.80%	Great Plains Enterprise
		Stanford Linear Accelerator Center	216.8	2.50%	no
		Thomas Jefferson Nat'l Accelerator Facility	82.2	0.90%	no
SC Totals	4	10 labs	2691	30.50%	
EE	Golden	Nat'l Renewable Energy Lab	182.4	2.10%	no
FE	NETL–GO-GO	Albany Research Center	0.85	0.00%	no
		Nat'l Energy Technology Lab	452.5	5.10%	no
FE Totals		2 labs	453.35	5.10%	
NE	Idaho	Argonne NL (West) (combining with INEL)	51.3	0.60%	
		Idaho Nat'l Engineering Lab	599.1	6.80%	unk

DOE PSO	Field Office	Labs	Lab Bud	% of total	Lab System?
NE Totals	1	1 or 2 labs	650.4	7.40%	
EM					
Not Clear who owns…		Bates Linear Accelerator Lab	16.1	0.20%	
		Battelle Columbus Lab	16.1	0.20%	
		Bettis Atomic Power Lab	360	4.10%	
		Environmental Measurements Lab	1.2	0.00%	
		Knolls Atomic Power Lab	263.8	3.00%	
		Lab for Energy-related Health Research	4.8	0.10%	
		New Brunswick Lab	6.8	0.10%	
		Radiological & Environmental Sciences Lab	---	0.00%	
		Remote Sensing Lab	6.8	0.10%	
		Savannah River Ecology Lab	---	0.00%	
subtotal–unk PSO owner		10 labs–2 have no R&D funding)	675.6	7.80%	
NNSA	Oakland	Lawrence Livermore NL	1,188	13.40%	Field Budget Submission System (FBS)
	Los Alamos	Los Alamos NL	1,562.4	17.70%	UBET (Universal Budget Estimating Tool)
	Kirland	Sandia NL	1,430.50	16.20%	FWP Tool
	Kansas City				
	Amarillo				
NNSA Totals	3 for labs	3 labs	4,181	47.3%	

DOE PSO	Field Office	Labs	Lab Bud	% of total	Lab System?
TOTAL	about 10?	27 labs (25 not counting RESL & SREL)	8,834		

Appendix D. Effort and Schedule Estimates

Appendix E. Submodules 1.1 and 1.2 Requirements Allocation

There are 396 numbered requirements identified during the requirements effort for Submodules 1.1 and 1.2. Table E-1 identifies the number allocated for software development for Releases 1 and 2.

Table E-1. Requirements Allocated to Software for Releases 1 and 2

Total requirements identified in draft	396
Requirements deleted prior to approval	34
# Approved Requirements	362
Requirements allocated to Submodule 1.5	49
# Submodules 1.1/1.2 Requirements	313
Requirements not allocated to software: Helpdesk (4) Project Guidance (7) System Requirements (14)	25
Requirements allocated to software for Release 1 and Release 2	288

An initial gap analysis done during Fall 2003 categorized the allocated requirements with respect to whether they would be met by configuring PDMLink or by customizing it. The table below identifies the number and percentage of allocated requirements that will be met by configuring and customizing PDMLink.[11]

Table E-2. Configuration and Customization Statistics

Requirements allocated to software	288
Total Number of requirements for configuration	170
Total Number of requirements for customization	118
Percent of requirements for configuration	59%
Percent of requirements for customization	41%

[11] Statistics are based upon an initial understanding of how PTC can be used to meet the requirements.

Appendix F. Acronyms and References

F.1 Acronym List

AHRQ	Agency for Health Care Research and Quality
API	Application Program Interface
BARC	Budget and Reporting Code System
CDCP	Centers for Disease Control and Prevention
CFR	Code of Federal Regulations
CME	Collaborative Management Environment
CNCS	Corporation for National and Community Service
COTS	Commercial-off-the-shelf
CRISP	Computer Retrieval of Information on Scientific Projects
CSC	Computer Sciences Corporation
DBA	Database Administrator
DOE	Department of Energy
DOeD	Department of Education
DOT	Department of Transportation
EDI	Electronic Data Interchange
EGAPS	electronic Grants and Awards Processing System
EMSL	Environmental Management Solutions Laboratory
ePME	electronic Portfolio Management Environment
ERP	Enterprise Resource Planning
eSNAP	electronic Simplified Non-competing Award Process
eWFO	electronic Work for Others
FAADS	Federal Assistance Awards Data System
FBS	Field Budget System
FCDS	Financial Control Distribution System
FDA	Food and Drug Administration
FTR	Final Technical Reports
FWP	Field Work Proposal
GIS	Grant Information System
GOTS	Government-off-the-shelf
GTA	Grants Technical Assistant
HRSA	Health Resources and Services Administration
HTML	Hypertext Markup Language
IAF	Inter-American Foundation
IAR	Internet Assisted Review
IIS	Internet Information Server
IT	Information Technology
LBNL	Lawrence Berkeley National Laboratory
LDAP	Lightweight Directory Access Protocol
LDRD	Laboratory Directed Research and Development

LLNL	Lawrence Livermore National Laboratory
MAPPS	Management and Proposal Preparation Submission
M&O	Management and Operating
NASA	National Aeronautics and Space Administration
NFE	No fund extensions
NIH	National Institutes of Health
NNSA	Nuclear Nonproliferation and National Security Administration
NSF	National Science Foundation
OASH	Office of Assistant Secretary of Health
OMB	Office of Management and Budget
ONR	Office of Naval Research
OSTP	Office of Scientific and Technical Programs
PDF	Portable Document Format
PDM	Product Data Management
PKI	Public Key Infrastructure
PLM	Product Life-Cycle Management
PMCS	Project Management Control System
PMTS	Program Management Tracking System
ProMIS	Project Management Information System
R&D	Research and Development
SAMHSA	Substance Abuse and Mental Health Services Administration
SRA	Scientific Review Administrator
UBET	Universal Budget Estimating Tool
UML	Unified Modeling Language
WTC	Workgroup Technology Corporation
XML	Extensible Mark Up Language

F.2 References

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