

RUP-based Requirements Development Applied to Product Lifecycle Management Systems

John S. Bowers, PE
*Sandia National
Laboratories*
jsbower@sandia.gov

Ann L. Hodges, CSEP
*Sandia National
Laboratories*
alhodge@sandia.gov

Darryl J. Melander
*Sandia National
Laboratories*
dmelan@sandia.gov

Abstract

This paper describes a RUP-based Requirements Development effort that is currently being utilized at Sandia National Laboratories for the development of an enterprise-wide Product Lifecycle Management system. An overview of the Product Lifecycle Management concept and the Rational Unified Process (RUP) is included in this paper. The description of the Requirements Development effort includes the elicitation, verification, and validation of the high-level requirements (or “stakeholder needs”) using classic requirements elicitation techniques (primarily interviews). The stakeholder needs are documented in a “Vision” artifact, which is described in this paper. “Actors” were identified and used to further refine and develop requirements with Use Cases, which represent the behavior of the system. Finally, the lessons learned from the Requirements Development activities for the enterprise-wide Product Lifecycle Management system are described.

1. Introduction

The “Rational Unified Process” (RUP), which is a comprehensive process framework that provides industry-tested practices for software and systems delivery and implementation an defective project management [1], is being used at Sandia National Laboratories in Albuquerque, NM for the development of the requirements for an enterprise-wide Product Lifecycle Management system. Requirements Development, which is one of the core RUP disciplines, is a key factor for the successful development of a software-based system [2]. The Requirements Development effort includes the elicitation, analysis, specification, and validation of the high-level requirements (or “stakeholder needs”) using classic elicitation techniques (primarily interviews). The stakeholder needs have been documented in a “Vision” document. “Actors” were identified and used to further refine and develop

requirements with “Use Cases”, which represent the behavior of the system. Sandia National Laboratories has faced several challenges when developing stakeholder needs, use cases, scenarios, and test cases for the continuing development of requirements for the enterprise-wide Product Lifecycle System.

2. Product Lifecycle Management

Product Lifecycle Management is an integrated business approach to manage and streamline the creation and dissemination of product and process data throughout an enterprise and throughout the product’s lifecycle [3]. Product Lifecycle Management systems are used in various industries to manage product data from conception to disposal. The benefits of a Product Lifecycle Management system include, but are not limited to, improved product or system quality, reduced prototyping costs, a framework for product optimization, reduced waste, and savings through the complete integration of engineering workflows [4].

The development of an enterprise-wide PLM system at a national laboratory is challenging. Sandia National Laboratories is organizationally divided into eleven major Divisions; and is programmatically divided into four Strategic Management Units. As the Divisions and SMUs have grown and changed over the last 60 years that Sandia National Laboratories has been in existence, many disparate information systems have evolved. Consequently, the enterprise-wide information systems, common tools, and processes need to be improved to effectively create an enterprise-wide Product Lifecycle Management system.

3. Rational Unified Process

The Rational Unified Process is a software engineering process characterized by a phased-based view of a project lifecycle and an iterative, risk-based approach to system development [5]. The RUP includes role definitions, activities, workflows, and suggested work products. IBM supplies a suite of

tools that support the use of the Rational Unified Process through the complete lifecycle of a software development project.

The Requirements discipline is one of the six core disciplines defined by the RUP. The other five are Business Modeling, Analysis & Design, Implementation, Testing, and Deployment. In addition to the core role types, the Rational Unified Process provides three supporting role types, namely Change and Configuration Management, Project Management, and Environment.

The requirements discipline in the Rational Unified Process is aimed at eliciting, structuring, maintaining, and managing the requirements that are formulated by the stakeholders. The requirements discipline plays an important role in the overall development process, because it is integrated with many of the activities in the other disciplines, which are directly or indirectly dependant on the requirements [2].

The Rational Unified Process includes four software development life cycle phases (i.e., Inception, Elaboration, Construction, and Transition). A phase culminates in a milestone, which reflects those objectives. Although Requirements Engineering continues throughout a project's lifecycle, requirements engineers are most active during the Inception and Elaboration phases. The Inception phase focuses on identifying the scope of the effort and gaining stakeholder agreement on the work to be done. The Elaboration phase focuses on understanding system architecture.

Currently, the requirements development activities for the enterprise-wide Product Lifecycle Management system have exited the Inception Phase, and have moved into the Elaboration Phase.

4. Requirements Engineering

The Requirements Engineering discipline ensures that the desired properties of a system are understood, agreed upon, and communicated. It includes the subcomponents of Requirements Development and Requirements Management (see Figure 1.). These sub-disciplines are recognized in other industry standards such as the Software Engineering Institute's Capability Maturity Model Integration model [6]. Requirements Engineering is a significant aspect of systems and software engineering, and is applied to hardware and software development projects. Elicitation, analysis, specification, and validation are the sub-disciplines/subcomponents of Requirements Development (see Figure 1.), and have been employed for the future enterprise-wide Product Lifecycle Management system at Sandia National Laboratories.

Requirements are defined at multiple levels, with each level addressing the viewpoint of a particular set of stakeholders. At each level, different levels of detail are captured. The lower levels include more detailed requirements. Figure 2. is a graphical overview of the relationships between the stakeholder needs, features and services, use cases, supplementary requirements, scenarios, and the test cases. Figure 2. also highlights the traceability of the requirements between the different levels of requirements in each level of the pyramid. According to Zielczynski [8], traceability is important for the following types of reasons:

- Verifying that an implementation fulfils all requirements (i.e., everything that the customer requested was implemented).
- Verifying that the application does only what is expected (i.e., don't implement something that the customer never asked for).
- Impact analysis (i.e., understanding the elements that will be affected when the project team considers adding a new requirement or changing an existing one).
- Helping with change management (i.e., when some requirements change, the project team wants to know which test cases should be redone to test the change).

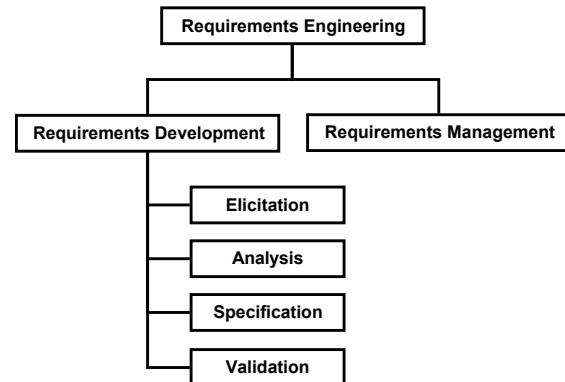


Figure 1. Requirements Engineering Domain [7]

5. Methodology

The Requirements Development team for the enterprise-wide Product Lifecycle Management system at Sandia National Laboratories conducted the elicitation activities by performing a key stakeholder analysis and then developed a survey instrument. This instrument consisted of a set of “CORE” questions, which established the interviewees’ Context, Opportunities for improvement (i.e., issues), Results from issues, and End vision. The survey instrument

was then used during a series of twenty-four interview sessions. Teams made up of two to four interviewers interviewed thirty-five key stakeholders. The interviewees represented various Divisions and Strategic Management Units throughout Sandia National Laboratories (including Sandia National Laboratories' operations in Livermore, CA).

The Requirements Development team evaluated the responses in the survey questionnaires, and extracted 855 "source statements" from the interview notes. The team then created a set of 126 "stakeholder needs statements" after analyzing source statements that were related to thirty-six "source categories".

Validation of the stakeholder needs statements was a crucial aspect of this project. The goal of the Requirements Development team was to demonstrate that the user and system requirements for the enterprise-wide Product Lifecycle Management system, as developed, would address the needs of the relevant stakeholders (e.g., "Are we solving the right problem?"). The notes from each interview were returned to the respective interviewees so that they could validate the Requirements Development team's notes, which were obtained during the interviews. Additionally, a Product Lifecycle Development consulting firm, which had been hired to assist the Product Lifecycle Program Office at Sandia National Laboratories, reviewed the stakeholder needs and provided feedback, gap identification, etc.

When the stakeholder and user needs were agreed upon, they were entered into RequisitePro (an IBM product that is used at Sandia National Laboratories for the Rational Unified Process). Subsequently, the features and services that were derived from the stakeholders and users needs, and the high-level features of the system were included in a "Vision" document, which is one of the standard artifacts resulting from the Rational Unified Process.

The next step in the process was to develop an initial set of high-level use cases for the enterprise-wide Product Lifecycle Management system. This is a daunting task for a large enterprise-wide system in an organization that has desperate systems, tools, and processes. The Requirements Development team made a decision to create use cases based upon the priorities that had been established by the Product Lifecycle Management Program Office. These priorities primarily included configuration management and project management. Additionally, the aforementioned Product Lifecycle Development consulting firm provided input for the identification and selection of use cases. Consequently, the categories and titles of the use cases included the following:

- Design
 - Create New Design
- System Development
 - Migrate Engineering Data
- Configuration Management
 - Request Change
 - Implement Change
 - Inactivate Records
- Project Management
 - Track and Report on Project Progress
 - Perform Risk Management
 - Develop a Risk Management Strategy
 - Identify Risks
 - Analyze Risks
 - Perform Risk Response Planning
 - Perform Risk Monitoring and Control

The use cases listed above were validated by reviews of each individual use case by one, or more, Subject Matter Experts.

Clearly, many other use cases need to be created for a system as large as an enterprise-wide Product Lifecycle Management system at a national laboratory.

The Requirement Development team's next set of tasks include, but are not limited to, the development of additional use cases, scenarios, test cases, and supplementary specifications.

PLM Requirements Pyramid

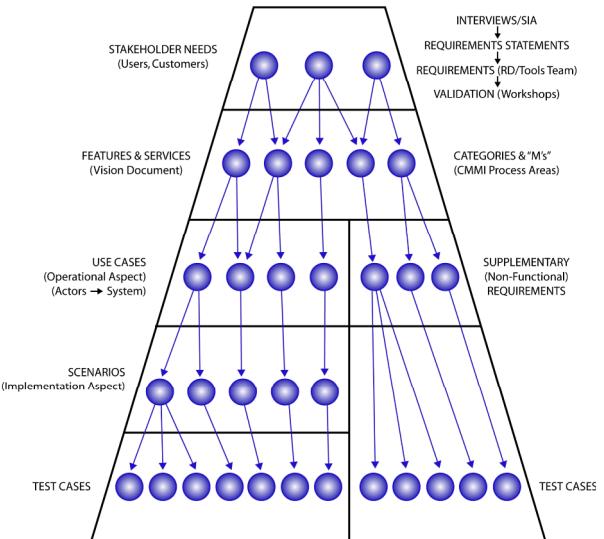


Figure 2. PLM Requirements Pyramid [8]

6. Lessons Learned

The Product Lifecycle Management effort at Sandia National Laboratories is a large undertaking. The associated requirements development effort by the Requirements Development team has yielded a number of insights that include, but are not limited to, the following:

- Determining scope is crucial – and difficult – for an effort of this magnitude. This is especially true for an effort labeled with the Product Lifecycle Management moniker. Product Lifecycle Management means different things to different people, ranging from simply managing CAD files to an all-inclusive system for the management of all business processes and data.
- Recognize early on that this is fundamentally an enterprise architecture effort, not a system implementation effort. Many are quick to jump to Information Technology issues and solutions, becoming impatient when software isn't deployed early on. Business architecture needs to be constructed first.
- This effort is an attempt to bring together multiple organizations, which have historically worked as stovepipes. This integration of disjoint business units occurs at the business layer, not the technology layer. The need for business architecture must be recognized early.
- Determining an appropriate methodology and desired work products early in the process. Leverage industry standards such as TOGAF.
- The Requirements Development team found that the traditional requirements elicitation activities such as stakeholder interviews are a good first activity to understand people's pain, but then requirements work needs to back off to let business architecture work take place.

7. Summary

The Requirements Development team at Sandia National Laboratories is a part-time team that is working on a relatively large enterprise-wide Product Lifecycle Management system development project. This team uses a rigorous requirements-based development process to provide a forum for communication with key stakeholders as well as a solid basis for requirements refinement and architectural development.

8. References

- [1] IBM Corporation, "Rational Unified Process" [Online] 29 January 2009.
<<http://www-01.ibm.com/software/awdtools/rup/>>
- [2] J. Passing, "Requirements Engineering in the Rational Unified Process" [Online] 17 August 2008.
<http://int3.de/res/RUP/RUP_Paper_JohannesPassing.pdf>.
- [3] F. Ameri and D. Dutta. "Product Lifecycle Management: closing the Knowledge Loops", *Computer-Aided Design & Applications*, Vol. 2, No. 5, 2005, pp.577-590.
- [4] CIMData, Inc., "Product Lifecycle Management: Empowering the Future of business", [Online] 18 June 2008, <www.cimdata.com>
- [5] Kruchten, P. *The Rational Unified Process - An Introduction - 3rd ed.*, Addison-Wesley, Upper Saddle River, NJ, 2004.
- [6] Chrissis, M. B., Konrad, M., Shrum, S., *CMMI: guidelines for process integration and product improvement - 2nd ed.*, Addison-Wesley, Upper Saddle River, NJ, 2007.
- [7] Wiegers, K. E., *Software Requirements - 2nd ed.*, Microsoft Press, Redmond, Washington, 2003.
- [8] Zielczynski, P., *Requirements Management Using IBM Rational RequisitePro*, IBM Press, Upper Saddle River, NJ, 2008.