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# The DoD Acquisition Environment and Software Product Lines

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## **About the Technical Note Series on Business and Acquisition Guidelines**

The Product Line Systems Program is publishing a series of technical notes designed to condense knowledge about product line acquisition and business practices into a concise and usable form for the DoD acquisition manager and practitioner. Each technical note will focus on one aspect of adopting software product line practice in the Department of Defense. Our objective is to provide practical guidance to early adopters on ways to integrate sound product line practices into their acquisitions. By investigating best commercial and government practices, the SEI is covering new ground to overcome challenges and increase the understanding, maturation, and transition of software product lines.

Together, the technical notes will lay down a conceptual foundation for DoD product line business and acquisition practices that is consistent with the SEI's product line framework [Clements 99b].

While we intend each technical note to be distributed and read as a standalone document, a brief overview of software product lines is provided in [Clements 99a]. If you are not familiar with this introductory material, we recommend you read it before reading this technical note. Other information on product line practices, including the latest version of the SEI's Framework for Software Product Line Practice, is available on the SEI's Web page at [http://www.sei.cmu.edu/activities/plp/plp\\_init.html](http://www.sei.cmu.edu/activities/plp/plp_init.html).

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## **Abstract**

Industrial experience clearly demonstrates that a product line approach for software-intensive systems can save money and result in faster time to field higher quality systems. Many within the DoD recognize the benefits of product lines, but also recognize that there are significant challenges to adopting this approach. Many of these challenges stem from the fact that the DoD is in the business of acquiring systems rather than developing them.

A key question is how can a software product line approach best be accommodated within the current DoD acquisition environment? In order to answer this question, this technical note examines three key DoD acquisition policies and regulations and their implications for launching a product line approach. This includes examining the DoD acquisition management process and DoD guidance on acquisition strategies that set the context for software product line acquisition planning. Sources of confusing guidance on developing acquisition strategies are examined and terms are defined to clarify what is meant by a product line acquisition strategy. The need for strategic acquisition planning in launching a product line is discussed and insight is provided on how it differs from traditional acquisition planning.





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## 1 Introduction

A product line approach to developing software-intensive systems offers great promise for delivering higher quality systems in a shorter time and at reduced cost [Bass 97, Bass 98, Bass 99]. While many commercial firms and DoD contractors are already engaged in product line practices, DoD organizations are still in the early stages of determining how product lines can best be applied in the DoD acquisition environment. In this technical note, we examine the DoD policies, regulations, and acquisition management process that govern DoD acquisitions and show how they relate to product line concepts and acquisition planning.

A product line is defined to be a group of products sharing a common, managed set of features that satisfy specific needs of a selected market or mission [Clements 99b]. It is most economical to build a software product line as a product family, where a product family is a group of systems built from a common set of assets. Thus, when we refer to a product line we always mean a product line that is implemented as a product family—i.e., one consisting of a related set of products that share a common architecture and are built from a common asset base.

Given this definition, there are at least three product line acquisition activities that need to be coordinated in the DoD acquisition environment. They are: (1) acquiring an architecture and other elements of an asset base to enable a product line approach, (2) acquiring software products that are developed using this asset base, and (3) acquiring the services to maintain and sustain the asset base while supporting the development and enhancement of derivative systems. Understanding how software product line concepts align with DoD policies, guidance, and regulations will help a DoD organization develop and implement a product line acquisition strategy<sup>1,2</sup> that can support these activities. Toward this end, we identify the key policies and regulations and explore some of their implications for developing and planning an acquisition strategy for a product line approach.

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<sup>1</sup> Other factors such as building a business case for the product line or creating a funding model, which may influence the acquisition strategy, will not be considered in this technical note. They are activities that need to be performed independent of whether or not the product line involves acquisition.

<sup>2</sup> Acquisition planning for a product line is also influenced by the culture of the DoD workplace. Cultural influences reflect the organizational values, management practices, and historical and localized ways of interpreting and complying with the regimen of policies and regulations that govern the work and the workforce. While these are beyond the scope of this technical note, insight into some of these cultural influences on the DoD acquisition environment can be obtained from [Bergey 98].

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## 2 DoD Documents Governing Acquisition

Our focus is on three documents that govern the DoD acquisition environment:

- DoD Directive 5000.1
- DoD Regulation 5000.2-R
- Federal Acquisition Regulations (FAR)

A basic understanding of these documents is necessary to understand how a software product line fits into the DoD acquisition environment.<sup>3</sup> A brief overview of their purpose follows.

### 2.1 DoD Directive 5000.1

DoD Directive 5000.1 of March 15, 1996 is the governing Department of Defense policy document on “*Defense Acquisition*.” This directive [DoD 5000.1] applies to *all* elements of the DoD and describes policies and broad management principles that are applicable to *all* DoD acquisition programs. Its stated purpose is “to establish a disciplined yet flexible management approach for acquiring quality products that satisfy the operational user’s needs.” To govern the implementation of these acquisition policies and principles, DoD 5000.2-R was established.

### 2.2 DoD Regulation 5000.2-R

DoD Regulation 5000.2-R of 1996 specifies “Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information Systems (MAIS).”<sup>4</sup> Its stated purpose is “to establish a simplified and flexible management framework for translating mission needs into stable, affordable, and well-managed programs” [DoD 5000.2-R]. The regulation is organized into six parts with six appendices and contains thousands of specific requirements pertaining to acquisition programs. In contrast to DoD 5000.2-R, which defines an overarching DoD acquisition management process and mandatory procedures, the FAR regulates acquisition planning and contracting.

### 2.3 Federal Acquisition Regulation (FAR)

The FAR governs all acquisition practices and codifies uniform policies and procedures to regulate the acquisition of supplies and services by all executive agencies [FAR 97]. The importance of the FAR is that it is the highest ranking statutory document and the common denominator in every acquisition initiated by DoD (or any other executive agency of the federal government, except where expressly excluded).

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<sup>3</sup> These regulatory documents also apply to other federal government agencies besides DoD.

<sup>4</sup> The terms MDAP and MAIS are major system classifications defined in Part 2 of DoD 5000.2-R.

As stated in DoD 5000.1,

“If there is any conflicting guidance pertaining to contracting, the Federal Acquisition Regulation and/or Defense Federal Acquisition Regulation Supplement take precedence over DoD Directive 5000.1 and DoD Regulation 5000.2-R.”

### 3 DoD Acquisition Policies Supporting Product Lines

Software product lines enable the achievement of many of the stated goals in DoD policy documents. All of the DoD 5000.1 policies summarized in Table 1 are compatible with a product line approach and the potential benefits that can be realized with such an approach.

DoD 5000.1 Policy and Abbreviated Excerpt	Section
<b>POLICY</b> "The primary objective of the defense acquisition system is to acquire <b>quality products</b> that satisfy the needs of the operational user with measurable improvements to mission accomplishment, in a timely manner, at a fair and reasonable price."	D
<b>Translating Operational Needs Into Stable, Affordable Programs</b>	
<i>Total System Approach:</i> "Acquisition programs shall be managed to optimize total system performance and minimize the cost of ownership."	D.1.e
<i>Non-Traditional Acquisition:</i> "Managers in the acquisition community shall make use of non-traditional acquisition techniques, such as ... evolutionary and incremental acquisition, and flexible technology insertion."	D.1.h
<b>Acquiring Quality Products</b>	
<i>Competition:</i> "Competition provides major incentives ... to enhance the application of advanced technology as well as a mechanism to obtain an advantageous price."	D.2.d
<i>Innovative Practices:</i> "The Department encourages Program Managers (PMs) to continually search for innovative practices that reduce cycle time, reduce cost, and encourage teamwork."	D.2.h
<i>Continuous Improvement:</i> "The Department shall continuously focus on implementing major improvements necessary to streamline the acquisition process, reduce infrastructure, and enhance customer service through process reengineering and technological breakthrough."	D.2.i
<i>Software-Intensive Systems:</i> "Software is a key element in DoD systems. It is critical that software developers have a successful past performance record, experience in the software domain or product line, a mature software development process, and evidence of use."	D.2.k
<b>Organizing for Efficiency and Effectiveness</b>	
<i>Teamwork:</i> "Cooperation and empowerment are essential. The acquisition community shall implement the concepts of Integrated Product and Process Development (IPPD) and Integrated Product Teams (IPTs) as extensively as possible."	D.3.c
<i>Tailoring:</i> "Tailoring may be applied to various aspects of the acquisition process, including program documentation, acquisition phases, decision reviews and levels."	D.3.e

Table 1: DoD 5000.1 Policy Supporting a Product Line Approach

These policies emphasize DoD goals of affordability, optimization, quality, efficiency, and effectiveness. These are exactly the goals that organizations adopting a product line approach have realized. Moreover, the approaches being promoted by these policies are highly suggestive of product line practice.

More information on DoD acquisition policies (and related guidance) is available on the acquisition Web sites we have listed in the compendium (Appendix A) at the end of this technical note.

## 4 DoD Acquisition Regulations Related to Product Lines

Mandatory procedures for acquiring major systems<sup>5</sup> are prescribed in DoD 5000.2-R. These requirements will influence choices in acquisition planning for product lines. Despite the comprehensive size of DoD 5000.2-R, there are only a relatively small number of requirements that directly relate to product lines.<sup>6</sup> These requirements are summarized in Tables 2-A and 2-B below.

<b>DoD 5000.2-R Section Topic (Abbreviated Excerpt)</b>	<b>Section</b>
<b>Evaluation of Requirements Based on Commercial Market Potential</b> “In developing system performance requirements, DoD Components shall evaluate how the desired performance requirements could reasonably be modified to facilitate the use of potential commercial or non-developmental items, components, specifications, open standards, processes, technology...”	2.3.1
<b>Open Systems</b> “PMs shall specify open systems objectives and document their approach for measuring the level of openness of systems, subsystems, and components to be acquired, and devise an open systems strategy to achieve these requirements. An open systems strategy focuses on fielding superior warfighting capability more quickly and more affordably by using multiple suppliers and commercially supported practices, products, specifications, and standards, which are selected based on performance, cost, industry acceptance, long term availability and supportability, and upgrade potential.”	3.3.1
<b>Commercial and Non-Developmental Items</b> “Market research and analysis shall be conducted to determine availability and suitability of commercial and non-developmental items (NDI).”	3.3.2.1
<b>Critical Product and Technology Competition</b> “The acquisition strategy shall describe the approaches the PM will use (e.g., requiring an open systems architecture, investing in alternate technology or product solutions, breaking out a subsystem or component, etc.) to establish or maintain access to competitive suppliers for critical areas at the system, subsystem, and component levels.”	3.3.2.4
<b>Competition</b> “Component breakout shall be considered on every program and shall be done when there are significant cost savings, when the technical or schedule risk of furnishing government items to the prime contractor is manageable, and when there are no other overriding Governmental interests.”	3.3.5.1

*Table 2-A: DoD 5000.2-R Requirements Related to a Product Line Approach*

<sup>5</sup> These mandatory procedures (and requirements) are also intended to serve as a model for other systems designated as being non-major systems.

<sup>6</sup> The requirements that are cited represent a very small part of the entire regulation and should not be construed as being an overview of DoD 5000.2-R requirements.

DoD 5000.2-R Section Topic (Abbreviated Excerpt)	Section
<p><b>Best Practices</b>  “PMs shall avoid imposing government-unique requirements that significantly increase industry compliance costs. Examples of practices designed to accomplish this direction include: open systems approach that emphasizes commercially supported practices, products, specifications, and standards; best value evaluation and award criteria; use of past performance in source selection, results of software capability evaluations; government-industry partnerships; and the use of pilot programs to explore innovative practices.”</p>	3.3.5.2
<p><b>Open Systems Design</b>  “PMs shall address the use of open standards in the design of all systems elements (mechanical, electrical, software, etc.). This approach shall be followed to develop a standards-based architecture in designing systems.”</p>	4.3.4
<p><b>Software Engineering</b>  “Software shall be managed and engineered using best processes and practices known to reduce cost, schedule, and performance risks.  It is DoD policy to design and develop software systems based on systems engineering principles, to include:  Developing <b>software system architectures</b> that support <b>open system concepts</b>; exploit <b>COTS computer systems products</b>; and provide for incremental improvements based on <b>modular, reusable, extensible software</b>; Identifying and <b>exploiting software reuse opportunities</b>, Government and commercial.”</p>	4.3.5
<p><b>Interoperability</b>  “Compatibility, interoperability and integration are key goals that...shall be specified and validated during the requirements generation process. The DoD JTA [Joint Technical Architecture] is mandatory for all emerging systems and systems upgrades.”</p>	4.3.9
<p><b>Work Breakdown Structure (WBS)</b>  “A program WBS shall be established that...shall define the total system to be developed or produced; display the total system as a <b>product-oriented family tree</b> composed of hardware, software, services, data, and facilities; and relate the elements of work to each other and to the end product.”</p>	4.4.2
<p><b>Integrated Product Teams (IPTs)</b>  “Working-Level IPTs [WIPTs] shall focus on a particular topic such as cost/performance, test, or contracting. An Integrating IPT shall coordinate WIPT efforts. The PM shall form an Integrating IPT to support development of strategies for acquisition and contracts, cost estimates, evaluation of alternatives, logistics management, cost-performance tradeoffs, etc.”</p>	5.4, 5.4.2

*Table 2-B: DoD 5000.2-R Requirements Related to Product Line Approach*

The significant aspect of these requirements, which apply to all major system acquisitions and are a model for others, is that product lines are inherently one of the most effective ways to realize them. Product line activities recommended by the SEI's Framework for Software Product Line Practice [Clements 99b] are fully responsive to these requirements. They include the following:

1. performing a domain analysis to identify the commonality and variability across the application domain and establish requirements for the product line architecture and other components of the asset base
2. conducting market research and analysis to determine the availability of suitable product line assets from commercial-off-the-shelf (COTS) products, legacy system, or NDI sources



3. seeking product line opportunities (at the system, subsystem, or component level) and establishing infrastructure support to promote and encourage participation in collaborative development/acquisition efforts among organizational units
4. providing specific guidance for building and communicating a business case, and developing a concept of operations for how a product line approach will work in the enterprise<sup>7</sup>
5. developing an acquisition strategy and implementing competitive contracting strategies, using performance-based specifications, and preparing request for proposals (RFPs) for acquiring product line assets and derivative products
6. ensuring the software product line is suitably integrated with the program's systems engineering process and the PM's open systems strategy
7. ensuring the software product line asset base (e.g., product line architecture, reusable software components) and derivative products are responsive to the system requirements (e.g., interoperability) that are allocated to software (at the system, subsystem, or component level)
8. ensuring mainstream product line activities (domain engineering and application engineering) and their subordinate tasks are reflected in a work breakdown structure (WBS) and appropriately "rolled-up" and integrated with the PM's overarching "program WBS"
9. forming IPTs to serve as a "virtual" product line organization to assist in performing tasks such as those identified above

These framework practices apply to both DoD and industry (including DoD contractors) and are representative of best practice. They are compatible with achieving conformance with DoD 5000.2-R's software-related requirements—especially those relating to component breakout, standards-based architecture, software best practices, interoperability, open-systems design, and use of integrated product teams to perform cost and schedule, performance, and risk tradeoffs.

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<sup>7</sup> Product Line "Operations" is one of the practice areas described in [Clements 99b].

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## 5 DoD Adoption of Product Lines and the FAR

There are many similarities in applying a product line approach in the DoD environment and in the commercial environment. Examination of product line practices and issues has shown that DoD product lines and industry product lines are more alike than different [Bergey 98]. From an acquisition standpoint, though, there are two basic differences between DoD and industry product line approaches that must be taken into account in implementing a product line.

One inherent difference is the predominant role that acquisition plays in the DoD environment [Bergey 98]. In the commercial sector, acquisition may also play a significant role (e.g., acquiring COTS products or other core assets), but it rarely applies to the entire process of acquiring the asset base, building derivative products using the asset base, and sustaining both over the life of the deployed systems. In the DoD environment, this is closer to the norm.

Another difference is that, in the federal government, procurement planning and RFP development *must comply* with the FAR. These regulations require government organizations to follow a fixed, and sometimes arduous, procurement process that spans RFP preparation, solicitation, proposal evaluation, contract award, and contract performance and administration. Other aspects of the FAR procurement system that are peculiar to DoD acquisition include the following:

- ensuring full and open competition
- disclosing beforehand the evaluation criteria to be used for contract award
- permitting only performance-based specifications
- choosing from a standard set of items (called data item descriptions) to describe contract deliverables
- limiting contracts to a maximum of five years

Since these requirements apply to all DoD acquisitions, there are ramifications for developing and implementing a software *product line acquisition strategy*. For example, if one contractor develops all the core assets, *ensuring full and open competition* for the development of follow-on products requires a strategy that addresses the issues of “ownership of data rights” and “liability” for the assets. The implications of *limiting contracts to a maximum of five years* are more obvious. Since the typical life of a product line is anticipated to be considerably longer, the acquisition strategy will have to address issues such as ensuring the continuity of product line operations when contracts are re-competed.

## 6 DoD Acquisition Management Process and Product Lines

DoD 5000.2-R prescribes a high-level acquisition process known as the *DoD Acquisition Management Process* to serve as a framework for specifying mandatory acquisition procedures and guide acquisition programs. While the DoD management process is primarily directed towards major system acquisition programs, it is intended to serve as a general model for all programs.<sup>8</sup> DoD 5000.2-R acknowledges that every acquisition is different and that a program need not follow the entire process. An acquisition can start anywhere in the process as long as risks are documented and agreed upon by the PM and MDA. As shown in Figure 1, this acquisition management process is structured into logical phases that are separated by major milestone decisions.

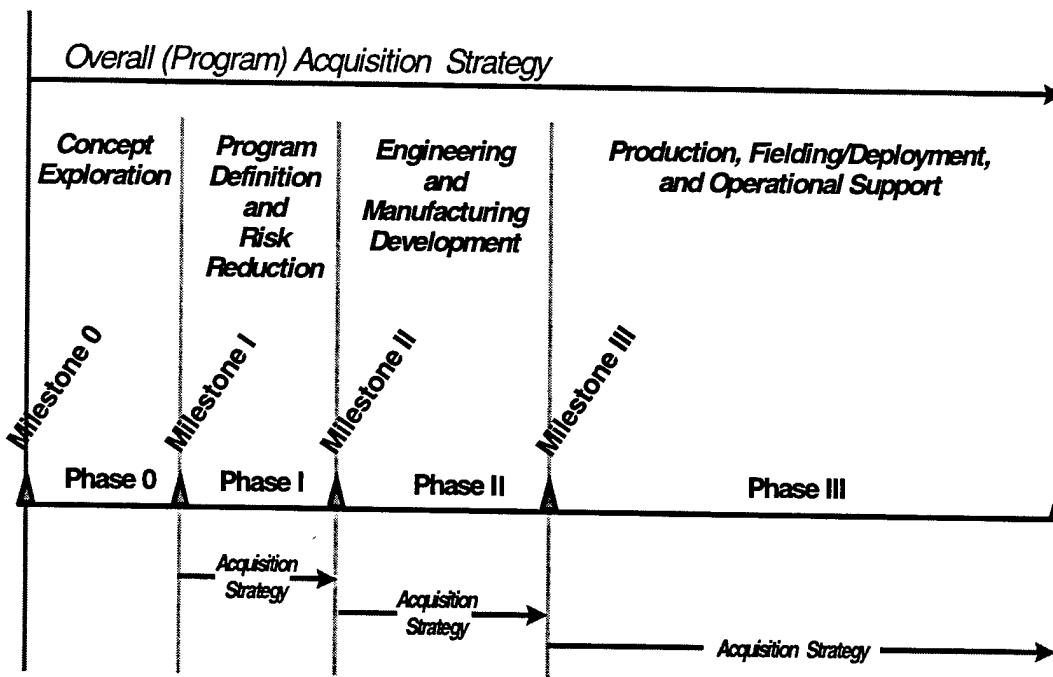


Figure 1: DoD Acquisition Management Process

This four-phase, event-driven management process is intended to manage risks and review affordability of acquisition programs on an incremental basis. Event-driven means the management process is explicitly linked to decision points that correspond to significant events and demonstrated accomplishments in the acquisition life cycle. These events, or decision points, are known as milestones. For each major milestone there is a prescribed

<sup>8</sup> PMs and milestone decision authorities (MDAs) for other than non-major programs shall generally adhere to the prescribed process; however, they shall appropriately tailor it to best match the conditions of their individual programs.

decision criterion corresponding to a set of core issues. The importance of this process is that it determines if the program should be approved and funded to proceed to the next phase.<sup>9</sup>

A product line approach may be adopted in any phase—i.e., it need not be initiated in Phase 0. For instance, many of our DoD product line collaborators are starting a product line in the operational support phase. They are strategically positioned and motivated to adopt a product line approach by virtue of being responsible for sustaining and enhancing groups of very similar operational systems. They have increased visibility into the benefits of adopting a product line and can leverage legacy system assets. And more importantly, they are able to quantify potential savings. By exploiting the synergism a product line approach offers, they are creating a more efficient and cost effective infrastructure for developing new software products and performing life cycle support.

We expect this trend will continue, where life cycle support organizations (engaged in enhancing and maintaining a number of similar but distinct systems) are the ones who take the initiative in starting a product line. The number of “green field” product lines (i.e., those starting from scratch) are expected to be fewer in number. This is due to the prevailing “stovepiped” means of funding development programs and the lack of a practical (and officially sanctioned) means for “pooling funds” to consolidate the acquisition of common products and services—independent of the life cycle phase (and color of money) of the participating projects.

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<sup>9</sup> Each of these phases and milestones is described in detail in a novel acquisition guide developed by the Naval Air Warfare Center Training Systems Division. The guide includes an easy-to-navigate graphical roadmap and is available at <http://www.ntsc.navy.mil/refer/acqguide/acqguide.htm>.

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## 7 DoD Acquisition Strategies and Product Lines

A focal point of the DoD acquisition management process (Figure 1) is the requirement for developing an “acquisition strategy.” However, “acquisition strategy” is a very overloaded term. In DoD 5000.2-R, for example, the term “acquisition strategy” is used *interchangeably* in reference to each of the following:

- the overall roadmap for program execution from program initiation through post-production support
- the overall (program) acquisition strategy (covering the entire DoD acquisition management process)
- the specific acquisition strategy for one phase of the acquisition management process
- the contracting strategy for how hardware/software will be purchased

One DoD guidance document states that “there is no common working definition for a standard acquisition strategy, no consistent agreement on its structure or composition, nor comprehensive guidance on how to develop and execute it” [Air Force 96]. While it is apparent that there is no common understanding or agreement, there are sources (for example, *Single Acquisition Management Plan Guide* [SAMP 96] and Acquisition Document Streamlining Workshop<sup>10</sup>) that provide more concrete guidance<sup>11</sup> for developing an “acquisition strategy,” but even the guidance from each of these sources is different.

Why is there so much confusion over “acquisition strategies” and a lack of consensus? We believe there are three interrelated reasons. The first, and most obvious, is that the term is not defined in the DoD acquisition policies and regulations. A second reason is that acquisition strategies and program strategies are generally treated as being synonymous, as are program goals and acquisition goals. Third, it is apparent that there is not one “acquisition strategy,” but several tiers of “acquisition strategies” and, unfortunately, the DoD policy and guidance documents do not clearly, or consistently, differentiate among them.

The question this raises is how can we sort through the regimen of available guidance on acquisition strategies and appropriately apply it to a product line approach?

First, it is important to recognize that DoD 5000.2-R views all programs as being exclusively *acquisition programs*. The underlying assumption is that *everything is being acquired* and nothing is being developed using organic resources. As a result, DoD 5000.2-R does not clearly differentiate between a program strategy and an acquisition strategy, or between program goals and acquisition goals. It treats them interchangeably, even though there are

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<sup>10</sup> Training materials from the Acquisition Document Streamlining Workshop offered through the BRTRC Institute. For more information, call BRTRC at (703) 205-1593.

<sup>11</sup> This guidance is based on established practices for obtaining approval of program plans and funds.

significant differences. The bottom line is that a large number of programmatic considerations involving funding and program management are included as being an integral part of the acquisition strategy.

Next, we need to define what we mean by an acquisition strategy. To begin, we define **acquisition** as *the process of obtaining products and services through contracting*.<sup>12</sup> This definition, which is consistent with both the FAR and the SEI's Software Acquisition Capability Maturity Model® (SA-CMM®), serves as a building block for the following definition:

*An acquisition strategy is a plan-of-action for achieving a specific goal or result through contracting for products<sup>13</sup> and services.*

The implication of this definition is that an acquisition strategy is *not* "the overall roadmap for program execution." Rather, the prescribed DoD acquisition management process, depicted in Figure 1, is "the overall roadmap for program execution"—not the acquisition strategy. In our usage, acquisition strategies are subordinate to this overarching process for managing major acquisition programs.

By refining our more general definition, we define a *software product line acquisition strategy* as *a plan-of-action<sup>14</sup> for achieving a specific product line goal or result through contracting for software products and services*. Accordingly, a software product line acquisition strategy<sup>15</sup> will differ from a program-level view of an "acquisition strategy." The requirements DoD 5000.2-R places on a program-level "acquisition strategy" are primarily directed towards major programs. The scope of these requirements includes both programmatic and acquisition considerations that go far beyond contracting strategies for a product line. This is especially true for DoD organizations that choose to launch a product line on a smaller scale, or who do not contract everything out, in which case the program strategy and acquisition strategy will clearly be different.

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<sup>12</sup> Contracting includes purchasing, buying, commissioning, licensing, leasing, and procuring of designated supplies and services via a formal written agreement.

<sup>13</sup> Instead of products, the FAR uses the term "supplies" to refer to tangible products and commodities.

<sup>14</sup> One that is potentially applicable to any phase of the DoD acquisition management process.

<sup>15</sup> A product line practice for "Developing and Implementing an Acquisition Strategy" will be described in the next release of the SEI's Product Line Framework.

We will be disciplined about using this definition to differentiate what we mean by a *software product line acquisition strategy* from DoD 5000.2-R's use of the term. This will lay the foundation for describing product line acquisition strategies that programs can adapt to meet their specific needs—independent of what particular acquisition phase (Figure 1) they may be in. This conceptual approach does not preclude anyone from suitably “rolling up” the selected *software product line acquisition strategy* and integrating it with a higher-tier strategy such as the PM's overall “acquisition strategy” at the program planning level.

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## 8 Product Line Acquisition Planning

All the DoD documents stress the need for acquisition planning. They recognize that proper planning is key to satisfying the system requirements and to ensuring a successful acquisition. Since product lines are more complex and require strategic thinking, planning is even more critical. Choosing to adopt a product line approach is a long term decision. It involves strategic planning to coordinate multiple projects for the long-range acquisition of a family of software systems.

Acquisition planning and acquisition strategies are pivotal to DoD adoption of a product line approach. We need to differentiate between an acquisition strategy and an acquisition plan. An acquisition plan is the artifact that is typically used to document the overall acquisition strategy, but the main thrust of the plan is to describe how the acquisition strategy is going to be implemented from a contractual standpoint. This is consistent with good practice and the FAR, which emphasizes contracting strategies and requires a plan for all acquisitions.

Developing an effective *software product line acquisition strategy* involves planning at several levels. As shown in Figure 2, the acquisition planning typically involves the parent program(s), participating projects, the designated organization responsible for implementing and sustaining the product line, and supporting teams involving key stakeholders. As the figure indicates, more planning details are required as the work progresses further down the organizational chain.

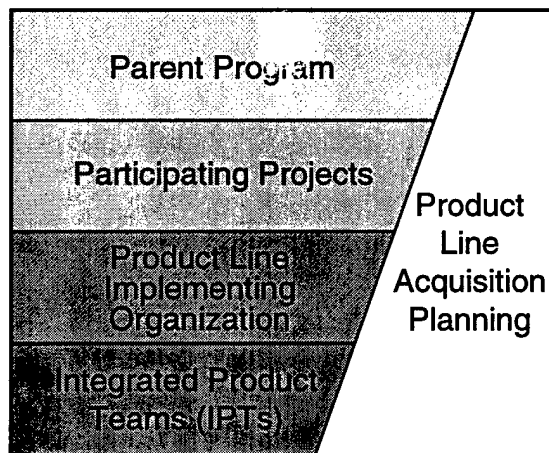


Figure 2: Organizational Elements Involved in Product Line Acquisition Planning

Since software product lines require strategic acquisition planning that complements the strategic mission planning, adoption may affect both program and project planning. The degree to which these organizational elements are involved in acquisition planning will vary



based upon the specific product line approach that is chosen and the scope of the product line.

Key elements of the acquisition strategy and the supporting planning revolve around one or more of the following types of contracting activities:

- acquiring a software architecture, common software components, and other elements of the asset base needed to enable a product line approach
- acquiring software products (at the system, subsystem, or component level) that are developed from this asset base
- acquiring services to manage, maintain, and sustain the asset base and provide the infrastructure support needed to assist projects (and users) engaged in modifying, assembling, instantiating, or generating multiple products using the asset base

A key aspect of product line acquisition planning is establishing the most effective contracting means (in accordance with the FAR) for implementing the selected *software product line acquisition strategy*. This will include determining

- the number and types of contracts needed to meet the acquisition goals and objectives
- how continuity of contractual products and services can best be sustained over the projected life of the product line and participating projects
- the detailed strategy for each contract, including answers to the following questions:
  - What should be specified in the RFP?
  - What should be included in the statement of work (SOW)?
  - What should be the basis for the technical evaluation criteria?
  - What kinds of incentives are appropriate?
  - What deliverables should be included?
  - What data rights should be incorporated?

How is the contractual approach for implementing a software product line different? It will typically involve multiple contracts, participation by multiple projects, close coupling and coordination of deliverables, interim deliverables and checkpoints to accommodate iteration in product line activities, and provisions in RFPs and SOWs to reflect accepted product line practice. Developing and implementing an acquisition strategy is an identified product line practice described in the SEI's Framework for Software Product Line Practice [Clements 99b].

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## 9 Summary

We have reviewed the key documents that govern DoD acquisition to (1) identify the policies, regulations, and processes that pertain to software product lines, (2) clarify their relationship to product line concepts, (3) understand their implications for launching a product line, and (4) understand the role they will play in developing a product line acquisition strategy and in acquisition planning. The following points summarize our findings and conclusions.

1. A product line approach is compatible with DoD acquisition policies. Both share the same high-level goals and product lines offer a viable means of achieving them.
2. The acquisition regulations include only a small number of requirements that directly pertain to software. A product line approach is not only compatible with all of these requirements, but represents a unifying and effective solution approach for complying with them. Moreover, the product line practices described in the SEI's Product Line Framework are consistent with meeting these requirements.
3. The FAR imposes some unique acquisition requirements on DoD and federal government organizations and closely regulates the pre-award contracting process. None of the constraints are "show-stoppers," but they have to be suitably taken into account in acquisition planning.
4. The DoD acquisition management process is oriented towards building major, one-of-a-kind systems from the ground up. However, nothing precludes adopting a product line approach in any phase of the process and suitably tailoring the process.
5. DoD 5000.2-R imposes many program-level "acquisition strategy" requirements that are above and beyond what might be needed for a software product line acquisition strategy. This situation is resolvable by appropriately defining an acquisition strategy and clearly differentiating between program goals and acquisition goals (and program strategies and acquisition strategies).
6. Acquisition planning will be a critical element in launching a product line. It involves strategic planning commensurate with the scope of the product line, the vision for product line operations, and the projected number of products and core assets that are to be developed and sustained over the life of the product line.

## Appendix A: Compendium of Acquisition Related Web Sites

WEB SITE	DESCRIPTION
<b>Defense Acquisition Revolution</b> <a href="http://www.acq.osd.mil/ar/">www.acq.osd.mil/ar/</a>	<b>Office of Deputy Under Secretary of Defense (DUSD) for Acquisition Reform (AR)</b> sponsors this Web site. Collects pertinent information dealing with the Defense Acquisition Revolution including the topics listed below:
<a href="http://www.acq.osd.mil/ar/#hot">www.acq.osd.mil/ar/#hot</a>	<b>Latest Topics in Acquisition Reform:</b> HOT Topics!   Upcoming Events   AR In the News
<a href="http://www.acq.osd.mil/ar/#org">www.acq.osd.mil/ar/#org</a>	<b>DUSD(AR) Organization</b> Organizational breakout for Acquisition Reform Office
<a href="http://www.acq.osd.mil/ar/#activities">www.acq.osd.mil/ar/#activities</a>	<b>AR Topics:</b> Initiatives   PATs   Working Groups   Focus Groups   Miscellaneous
<a href="http://www.acq.osd.mil/ar/#library">www.acq.osd.mil/ar/#library</a>	<b>Reference Library:</b> Laws   Regulations (FAR)   Directives (5000 Series)   <i>Acquisition Deskbook</i>   Periodicals   Success Stories   Other (Policy docs, Speeches, etc.). Includes links to the FAR, DoD 5000.1, and DoD 5000.2-R.
<a href="http://www.acq.osd.mil/ar/#sites">www.acq.osd.mil/ar/#sites</a>	<b>Other AR Sites:</b> A comprehensive listing of acquisition links available on the Web. Includes links to education and training, and Air Force, Army, and Navy acquisition sites.
<b>MIL-STD-881B, Work Breakdown Structures</b> <a href="http://www.acq.osd.mil/pm/newpolicy/wbs/wbs.html">www.acq.osd.mil/pm/newpolicy/wbs/wbs.html</a>	MIL-HDBK-881 provides a consistent and visible framework for defense materiel items and contracts within a program to promote improved communication throughout the acquisition process.
<b>STSC's Guidelines for Successful Acquisition Management of Software-Intensive Systems</b> <a href="http://www.stsc.hill.af.mil/stscguid.html">www.stsc.hill.af.mil/stscguid.html</a>	These guidelines cover the gamut of software-intensive systems acquisition and management activities, from pre-program strategic planning to post-deployment software support. They are divided into three essential areas for program success. Part I, Introduction, lays the groundwork. Part II, Engineering, provides the meat. Part III, Management, brings it all together.
<b>SEI's Software Acquisition Capability Maturity Model (SA-CMM)</b> <a href="http://www.sei.cmu.edu/arm/SA-CMM.html">www.sei.cmu.edu/arm/SA-CMM.html</a>	The SA-CMM is a model for benchmarking and the software acquisition process. The model follows the same architecture as the Capability Maturity Model for Software (SW-CMM), but with a unique emphasis on acquisition issues and the needs of individuals and groups who are planning and managing software acquisition efforts. Each maturity level indicates an acquisition process capability and has several key process areas (KPA's). Each KPA has goals and common features and organizational practices intended to institutionalize common practice.
<b>The Federal Acquisition Virtual Library</b> <a href="http://www.arnet.gov/references/references.html">www.arnet.gov/references/references.html</a>	Provides links to numerous other federal acquisition resources on the Web.

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## References

- [Air Force 96] *Guidelines for Successful Acquisition and Management of Software-Intensive Systems*, Chapter 12 [online]. Department of the Air Force, Software Technology Support Center, September 1996. Available WWW: <URL: <http://www.stsc.hill.af.mil/stscguid.html>>.
- [Bass 97] Bass, Len; Clements, Paul; Cohen, Sholom; Northrop, Linda; & Withey, James. *Product Line Practice Workshop Report (CMU/SEI-97-TR-003, ADA327610)*. Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, 1997.
- [Bass 98] Bass, Len; Chastek, Gary; Clements, Paul; Northrop, Linda; Smith, Dennis; & Withey, James. *Second Product Line Practice Workshop Report (CMU/SEI-98-TR-015, ADA354681)*. Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, 1998.
- [Bass 99] Bass, Len; Campbell, Grady; Clements, Paul; Northrop, Linda; & Smith, Dennis. *Third Product Line Practice Workshop Report (CMU/SEI-99-TR-003)*. Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, 1999.
- [Bergey 98] Bergey, John, et al. *DoD Product Line Practice Workshop Report (CMU/SEI-98-TR-007, ADA346252)*. Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, 1998.
- [Clements 99a] Clements, Paul. "Software Product Lines: A New Paradigm for the New Century." *Crosstalk 12*, 2 (February 1999): 20-22.
- [Clements 99b] Clements, Paul & Northrop, Linda. *A Framework for Software Product Line Practice, Version 1.1* [online]. Pittsburgh, Pa.: Software Engineering Institute, Carnegie Mellon University, March 1999. Available WWW: <URL: <http://www.sei.cmu.edu/plp/framework.html>>.
- [DoD 5000.1] DoD Directive 5000.1, *Defense Acquisition* [online]. U.S. Department of Defense, March 1996. Available WWW: <URL: <http://www.acq.osd.mil/api/asm/product.html>>.

- [DoD 5000.2-R] DoD Regulation 5000.2, *Mandatory Procedures for Major Defense Acquisition Programs (MDAPs) and Major Automated Information System (MAIS) Acquisition Programs* [online]. U.S. Department of Defense, October 6, 1997 (date of Change 2). Available WWW: <URL: <http://www.acq.osd.mil/api/asm/product.html>>.
- [FAR 97] *Federal Acquisition Regulation, FAC 97* [online]. October 10, 1997. Available WWW: <URL: <http://www.arnet.gov/far/index.htm>>.
- [SAMP 96] *Single Acquisition Management Plan (SAMP) Guide* [online]. Available WWW: <URL: [http://www.safaq.hq.af.mil/acq\\_ref/bolts/bolt7/](http://www.safaq.hq.af.mil/acq_ref/bolts/bolt7/)>.

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## Feedback and Contact

### SEI Technical Notes on Business and Acquisition Guidelines for Product Lines

Comments or suggestions about this document or the series of technical notes on *software product line business and acquisition guidelines* are welcome. We want this series to be responsive to the needs of DoD and government personnel involved in the business and acquisition aspects of implementing software product lines. To that end, comments concerning this technical note, inclusion of other topics, or any other issues or concerns will be of great value in continuing this series. Comments or suggestions should be sent to

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