

# A Concept of Operations for Product Lines

*Software product line technology has been adopted to achieve savings while improving product quality and delivery time. To achieve these results, several Department of Defense organizations developed a process for fielding the product line and captured that process in a concept of operations (CONOPS). This article introduces the concepts behind the CONOPS and provides guidance for an organization wishing to adopt a product line approach.*

## Moving to a Product Line Approach

Your organization has studied the advantages of product lines [1, 2] and is developing an acquisition approach [3]. What comes next? When an organization decides to move to a product line approach for acquiring or developing software, it must address several key issues:

1. What constitutes the product line?
2. How is the product line introduced?
3. What are the key organizational elements involved in defining, developing, and fielding the product line?

The operational concept for a product line should be documented as a CONOPS. CONOPS conveys the operational nature of the process for fielding a product line. An organization develops a CONOPS to establish the desired product line approach it wishes to take, and to document decisions that define actions and organizational structure needed to put the approach into operation.

## Aspects of CONOPS Peculiar to Product Lines

The concept of operations for a product line will contain:

1. The strategies, tactics, policies, and constraints that describe *how* the process will be used to field the product line.
2. The organizations, activities, and interactions that describe *who* will participate in fielding the product line and *what* these stakeholders do in that process.
3. The specific operational processes, in overview fashion, that provide a process model for fielding the product line in terms of *when* and in *what* order these operation processes take place, including dependencies, concurrencies, etc.

## Application of CONOPS to Core Asset, Product Development/Acquisition

A CONOPS should address a number of key product line issues, both for core asset and product development. An organization needs to address these issues as it makes product line decisions. For

product development, the CONOPS helps address needs of program managers, developers, and others in product oversight or decision-making roles. Issues may be grouped into categories as shown in Table 1.

An organization develops a CONOPS to establish the desired product line approach it wishes to take. The

CONOPS should contain a detailed description of this approach, including decisions defining the approach and organizational structure needed to put it into operation. The CONOPS may possibly present alternatives.

## Specific CONOPS Practices

The CONOPS may not be strictly

Categories	Core Asset Development	Product Development
Key decisions	Process and organization for developing core assets; key action steps for putting the CONOPS into effect	Process and organization for developing products in the product line
Components	Known components or elements in the product line including the product line scope, the architecture and other assets, and the product line activities	Effects of using product line assets in developing products
Context	Relationships among the stakeholders and sources for asset development: legacy systems and assets, asset developers and product users	Relationships among the stakeholders and assets for product development: product line assets, asset developers, product developers and product users
Activities	Sequence of activities moving from product line scoping, through architecture, and component development. Product line sustainment	Activities for using core assets in the development of individual products
Organizational elements	Organizational elements and the role they play in fielding the product line	Organizational elements and the role they play in the development of product line products
Rationale	Rationale for moving to a product line approach as well as risks	Rationale for using product line assets as bases for product development
Integration	Tie together the above elements to provide guidance in development activities such as the development of component assets and the use of the architecture and assets in producing products	Production plan for products in the product line. Guidance is especially important for reflecting the results of using core assets in product developments to support their continued improvement

Table 1. Key product line issues to be addressed by CONOPS.

followed due to costs, scheduling, performance, capability, or insufficient commonality. For example, a set of requirements for a new system may fall outside the bounds of the existing assets. The product line organization must determine if:

1. This system should be developed outside the product line.
2. The new requirements should become an area for continued growth within the product line.
3. Potential users should be encouraged to tailor requirements to capabilities already accommodated within the product line.
4. Establishing a new product line is recommended.

All of these factors must be considered as part of the business analysis for meeting the needs of candidate users and should be spelled out in the concept of operations or accompanying documents.

Understanding potential user needs, implementing solutions, and managing product evolution goes beyond creating an architecture and components. It requires a systematic and comprehensive approach (i.e., the product line concept of operations) to marshal existing resources and identify additional methods of lowering costs of providing thorough use of product line assets. Strong management support is key, and identifying a champion who will assume responsibility for managing and facilitating the effort.

The following practices are essential elements to be considered in putting the CONOPS into effect:

#### **Selecting a Product Line Approach Champion**

The champion must be the owner of the CONOPS and employ available resources in concert with each other according to the plan. The champion is responsible for defining and articulating the integrated vision for assets and for the product line CONOPS. Providing for the existence of an architecture is not enough to ensure a product line will result. It takes a concerted, well-coordinated effort to overcome technical, cultural, political, and programmatic obstacles.

#### **Architecture-Based Development**

CONOPS results are predicated on the use of architecture-based development. Much is implied by this approach to sys-

tem design. Fundamental is establishing a development process centered on a software architecture to address common and mission-unique requirements and applied to developing the system in a prescriptive manner.

The CONOPS should help an organization integrate its architecture-based development plans to manage, design, implement, and test product line assets as well as systems in the product line. The CONOPS describes elements of architecture-based development:

- A set of program plans (program management, systems engineering management, software development, configuration management, test and evaluation, integration, etc.).
- The architecture description document.
- A set of architectural templates or tools that automate the representation and use of architectural templates.
- Typical development tools including those for detailed design and coding, configuration management, compilers, graphical user interface builders, etc.
- Documentation tools.

Program plans identified by the concept of operations should establish the management infrastructure and reporting elements similar to the structure of the architecture. The CONOPS should describe the estimation and tracking processes that are keyed to this structure. The CONOPS should also indicate how prototyping, evaluation, or other efforts will support validation of architectural decisions.

#### **Planning the Impact of Transition to the CONOPS.**

The transition to a product line strategy may require significant change in existing organizations. Any plan for transition must address the impact of change to organization, management, and acquisition elements.

#### **Organization**

The product line approach requires special attention to bring together core competencies from across existing organizational structures. The concept of operations spells out organizational restructuring that will enable concentration and sharing of personnel and skills, leading to greater overall productivity.

#### **Management**

The concept of operations must address management strategies that support the product line. New incentives will be needed to support the management and use of a product line approach. The CONOPS must address managerial changes that come with adopting a product line approach, including:

- Establishing promotion and reward structures.
- Breaking the *not invented here syndrome*.
- Integrating efforts across organizational boundaries by relying on support and assets from other parts of the organization or other organizations.
- Recognizing that the development of mission-unique applications requires more than just component integration.

#### **Acquisition**

The CONOPS must address investment strategies that support a series of systems based on a common infrastructure. A CONOPS makes the case that systems need to be acquired through methods that encourage using the existing product line infrastructure and leveraging existing assets. Acquisition must also include direct support for sustaining and enhancing the infrastructure to support future needs.

Alternative approaches should be considered in formulating financial aspects of the CONOPS. These may include:

- Pooling funds from all the systems that fall within a product line to pursue product line development.
- Designating a single program to manage the common infrastructure.
- Using existing commercial-off-the-shelf software products.

#### **Product Line Asset Utilization**

A concept of operations establishes procedures to ensure every proposed program is examined for similarities with existing systems in mission and underlying functions. The goal is to focus new development on unprecedented areas and reuse product line assets as much as possible. Reuse of assets includes much more than software components. Design, architecture, requirements, and models are all assets for reuse. The acquisition approach for accommodating new programs should encourage leveraging past investments to the fullest and contributing assets for use in future efforts.

## Support Strategy

A basic element of a concept of operations strategy is continued maintenance and enhancement of product lines and corresponding architectures. A CONOPS defines the organizational structure that provides this support and its interaction with product development. Updated assets are provided to various customers/users according to maintenance/upgrade agreements established at the initiation of development of new members of the product line. Maintenance and support of the product line architectures and components are a natural consequence of the product line development strategy.

## CONOPS Risks

### Failure to Identify a Product Line Champion

Success of the product line requires strong management in the form of a product line champion. For most organizations, the nontechnical challenges alone will limit success unless one individual is given and assumes management responsibility. Technical activities involved in fielding a product line, from conceptualization to asset development to producing the first products may take two or more years. The champion must maintain the vision during this *black hole* period. In particular, the product line champion needs to take early initiative and oversee development of a concept of operations to solidify the conceptual approach and obtain the buy-in of key stakeholders.

### Lack of Appropriate Product Line Vision

A CONOPS will often be written a year or more before assets are built and

products start to flow from the product line. Developers must focus attention on where the product line should be three to 10 years hence in order to plan for full transition. The organization must be able to address the development of assets, their use and refinement in specific products, and potentially, transition of the product line approach throughout the enterprise.

### Failure to Maintain the CONOPS.

The concept of operations is not meant to be completed and placed on a shelf. It should be constantly reviewed and revised as the product line is fielded and the product line evolves. As a document released early in the process of fielding a product line, the CONOPS can only provide a starting point for product line development. Lessons learned in asset development, initial product development using assets, and sustainment of the assets must be factored back. If the CONOPS is not maintained in spirit, if not as a formal document, the product line may not successfully evolve to address new customer needs.

To help offset these risks, *Guidelines for Developing a Product Line Concept of Operations* [5] has been developed that can be suitably applied by an organization to meet its specific needs and circumstances. The guidelines and scenarios help an organization that has proposed a product line. This document provides excerpts from sample CONOPS and details the class of information to be contained in each section of a CONOPS.

## References

1. Clements, Paul. *Software Product Lines: A New Paradigm for a New Century*. *CROSS-TALK*, February, 1999, pp. 20-22.

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4. ANSI/AIAA. *Guide for the Preparation of Operational Concept Documents*. ANSI/AIAA G-043-1992
5. Cohen, Sholom. *Guidelines for Developing a Product Line Concept of Operations* (CMU/SEI-99-TR-008). Pittsburgh, Pa. Software Engineering Institute, 1999.

## About the Author



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Due to an anticipatedly high level of submissions, our CMMI<sup>SM</sup> theme will carry over to a second issue (Aug. 2000), for which the deadline is April 3. Other upcoming themes and submission deadlines as amended are:

**September 2000**

***COTS***

**Deadline: May 1**

**October 2000**

***Network Security***

**Deadline: June 1**

**November 2000**

***Software Acquisition***

**Deadline: July 1**

**December 2000**

***Project Management***

**Deadline: August 1**

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