

3. Domain-Specific Engineering

Software product engineering is an approach for building a singular evolving software product that will suit the needs of a particular customer (a one-of-a-kind product) or of a simple market (a one-size-fits-all product), The *Domain-specific Engineering (DsE) methodology* builds on and extends that approach to provide the means to rapidly build any of an envisioned set of similar software-based products.

The rationale for a DsE effort is recognition of a coherent market for similar products and the associated competence to build such products. The ultimate result of a DsE effort is a set of similar products in use by customers comprising a targeted market but its enabling result is a *domain*, representing the knowledge (expressed in a product family) and expertise (expressed in a product manufacturing capability) required to build those products.

The notion of a coherent market is that it corresponds to a set of potential customers whose needs are similar but differ due to discernible rationale. Such rationale must be sufficient to justify products that differ but only in aspects of their behavior that are essential from a customer perspective, eliminating arbitrary and incidental differences. A key premise underlying DsE is that similar problems are amenable to similar solutions, the result being similar products.

The motivation for a focus on similar products is the opportunity it provides to leverage development effort involved in building multiple products and evolving them over time. The focus of DsE is having the means to provide each customer with a product that is a good fit to their specific needs, both initially and as those needs change, with a fraction of the time and effort required to build a product conventionally.

However, both market composition and associated customer needs change over time. Therefore, an objective for DsE is to maintain alignment between domain capabilities and aggregate market needs as well as individual customer needs. This results in a domain and market that coevolve— the domain changes as market needs change but also influences the directions in which the market can beneficially change.

Beyond encompassing all aspects of software product engineering, DsE addresses key elements of its context for a system-level scope: the totality of program management concerns, systems engineering, hardware engineering, and customer practices. This broadened scope enables a unified “whole-product” perspective for a disciplined approach to the coordinated development of a collection of similar and related software-based products. Furthermore, DsE targets building enhanced means by which products are realized in hardware and software, along with the associated materials and practices needed for the effective production and use of those products.

The DsE Program Model

A DsE product development program establishes a coherent market focus for a domain, defines a product family that encompasses the products needed by customers comprising that market, creates the means by which projects can build instances of that family, and works with customers to build the products that fit their specific needs. The DsE program model has 3 elements that form an iterative tripartite process (Figure 3.0-1):

- *Program Management*, the process by which an enterprise initiates and sustains a viable effort to engineer and manufacture products for an associated coherent market
- *Domain Engineering*, the program-defined process for developing a domain, as the means by which projects can build similar products
- *Product Manufacturing*, the domain-defined process by which a customized product is built for a designated customer

A program initiates manufacturing projects for customers whose needs are a good fit to existing domain capabilities and planned investments in domain evolution. Each manufacturing project is committed to working with a particular customer to collaboratively determine the specific evolving needs of that customer and building a product that is a best-fit to those needs. The domain engineering effort is committed to working with all projects to ensure each has the capabilities needed to build its product, consistent with program goals and tradeoffs for the domain and market as a whole.

Engineering effort is leveraged across past, current, and future products to create a

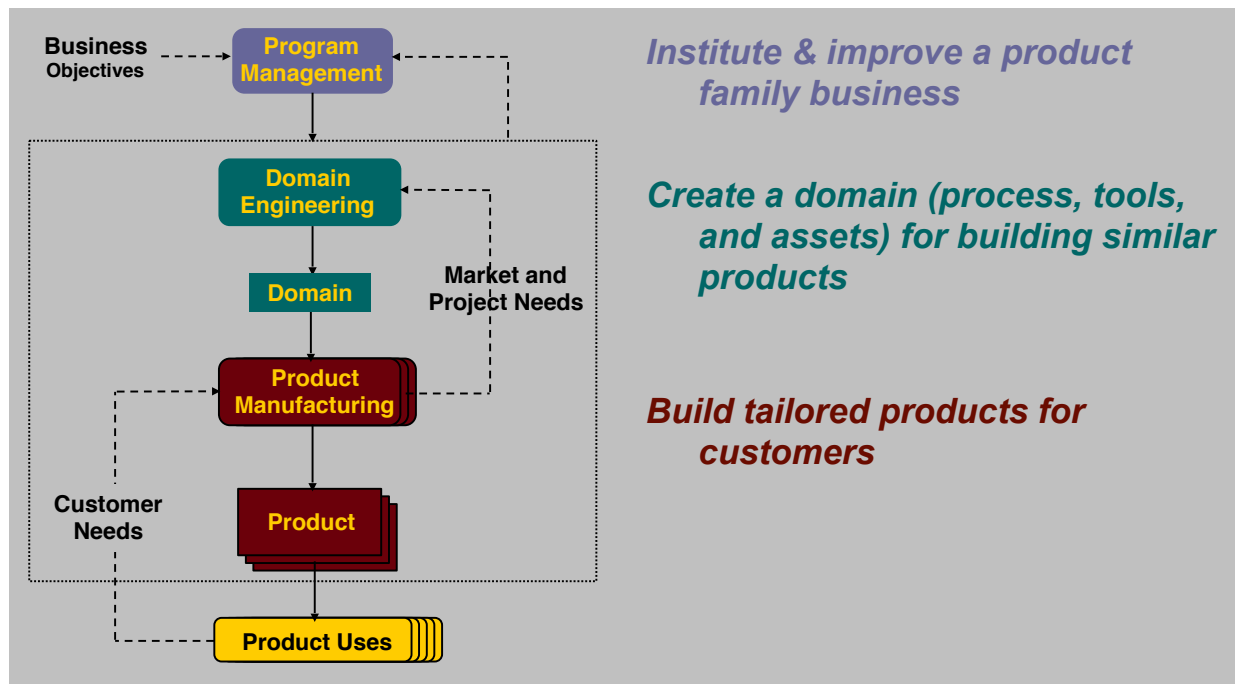


Figure 3.0-1. The DsE Tripartite Process

manufacturing capability that streamlines the effort needed to build any individual product. A product can be derived and iteratively refined as development proceeds and the customer's specific needs become better understood. A project may derive multiple candidate products concurrently to allow a customer to explore uncertainties and tradeoffs. Each deployed product can then be progressively modified as its customer's needs and circumstances change over time. As market needs and domain capabilities coevolve over time, projects are able to revise their products to provide improved capabilities to their customers.

Objectives of a DsE Approach

A product development program chartered to focus on the needs of customers comprising a coherent market will have two complementary objectives that, relative to basic software product engineering, motivate adopting a DsE approach:

- Predictably building high-quality products that are a timely fit to each customer's actual needs

- Focusing development effort on the resolution of key deferred decisions that distinguish how customers' needs differ
- Systematically recognizing and resolving uncertainty, change, and diversity in building a product
- Establishing a collaborative relationship between each product manufacturing project and its customer to determine their specific essential needs and build a responsive product
- Tracing differences in the behaviors of derived products to differences in how deferred decisions can be resolved (in that every derivable product will correspond to a unique resolution of those decisions) to build a better fit
- Deriving alternative and partial versions of a product by means of differing / partial resolutions of deferred decisions (as a medium for refining understanding of customer needs, to demonstrate progress toward delivering an acceptable product, or to enable comparative evaluations of problem or solution alternatives and tradeoffs)
- Providing each customer with a series of revised products over time as their needs and circumstances change
- Making better use of enterprise resources and technical competence by focusing on the aggregate needs of a targeted coherent market:
 - Establishing a shared framework for disciplined engineering and manufacturing practices
 - Developing a shared understanding of problems and solutions across projects targeting similar needs
 - Reducing development effort by standardizing common aspects of problems and solutions so as to focus more narrowly on the resolution of key deferred decisions that are sufficient to characterize a customer's particular product capability needs and evaluation of the resulting product in terms of those decisions

- Eliminating redundant work and improving product quality through development of standardized assets for flexible reuse in creating products
- Preferring flexible alignment of the program to its market (shared needs) over strict alignment of each project to its customer (divergent needs), while accommodating essential differences
- Sharing improvements across products with reduced effort
- Evolving domain capabilities over time as market/customer needs and enabling technology change

Balancing Standardization and Customization for a Responsive Product

The benefits of the DsE approach derive from the inherent tension it relieves between cost-reducing standardization and needs-fitting customization [Figure 3.0-2]. To build a singular product depends on either focusing on a single customer's needs (one-of-a-kind) or compromising the product's fit to each customer so as to exploit the similarities in multiple customers' needs (one-size-fits-all). By building a product family appropriate to a targeted coherent market, the needs of every customer is expressed in the product family from which each customer's specific needs can drive the derivation of a customized instance product.

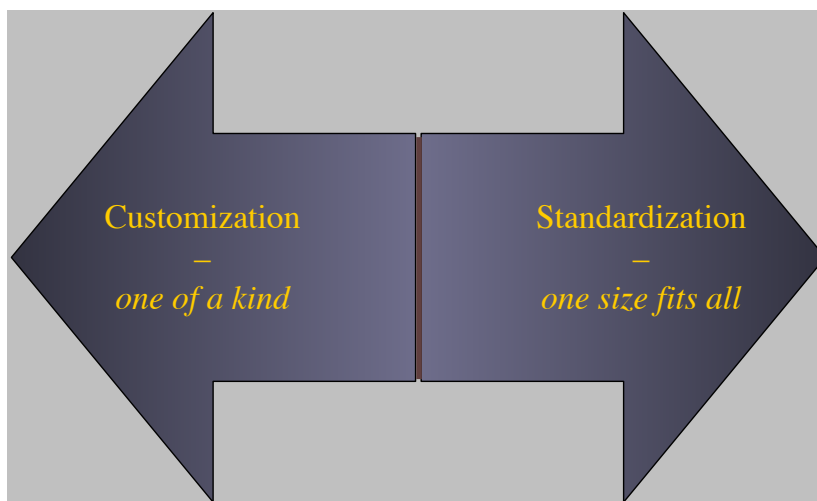


Figure 3.0-2. An inherent tension

Standardization and customization each have implications for the timely development of responsive products:

- Implications of Cost-Reducing Standardization
 - Program management focuses on domain investment, with a goal of reducing time and cost relative to single-product crafting.
 - Market-focused business objectives implies explicit limits on feasible product diversity.
 - The development process is reduced to its essentials for a particular market. Projects are able to focus on resolving key problem/solution alternatives, based on systematic reuse of assets across projects.
- Implications of Needs-Fitting Customization
 - Program marketing is focused on promoting products that are viably based on domain capabilities, with more accurate cost-risk estimates.
 - Each customer gets a product that better fits their actual needs and preferred practices over a one-size-fits-all product and faster with reduced lifetime cost over a one-of-a-kind product.

{(here or in 3.1) discuss cost of domain engineering as essentially cost of development and evolution of one product plus incremental increase due to addressing diversity among a set of similar products, reduced cost of product manufacture over 1-N singular products (noting that 1 product requires some exploration of alternatives, work that is then discarded), providing an overall gain in overall productivity with DsE; consider technical debt vs predictive investment; note that market-significant alternatives are also considered during conventional development of a given product but then discarded as not relevant for the current realization of that product}