

3.3 DsE Product Manufacturing

Product manufacturing, as the “manufacturing” element of DsE, defines the nature of a project to specify, build, support, and evolve a product that will meet the changing needs of a designated customer within a targeted market. A project works collaboratively with its customer to understand and specify current needs, derive a customized product that is a suitable fit to those needs, and support effective use of the product over time. As those needs (or understanding of actual needs) change, the project is able to quickly provide a revised product that reflects those changes.

A product is a realization of a solution to an associated problem within the context of a domain-targeted product family. The product manufacturing process is an abstracted realization of the basic software product engineering process limited to building instances of the product family that addresses a specified market-directed domain. The result of performing this process is a complete product model as determined by domain engineering (e.g., as defined in chapter 2) for a product that addresses a customer’s particular needs.

{This section describes only the general nature of high-productivity product manufacturing. The process for any particular domain may differ from this ideal depending on the program’s business objectives and market circumstances as well as the program’s technical capabilities and resources allocated to domain engineering. In particular, the process engineering element of domain engineering defines how a program’s projects will perform product manufacturing.}

Conceptually, the product manufacturing project model has five elements [Figure 3.3-1]: project management, product specification, product realization, product evaluation, and product delivery. Performance of product manufacturing relies on developer competence and customer needs (as with any approach to product development), using a supporting domain infrastructure in which a product specification, the product family, and a product model are appropriately represented for the domain.

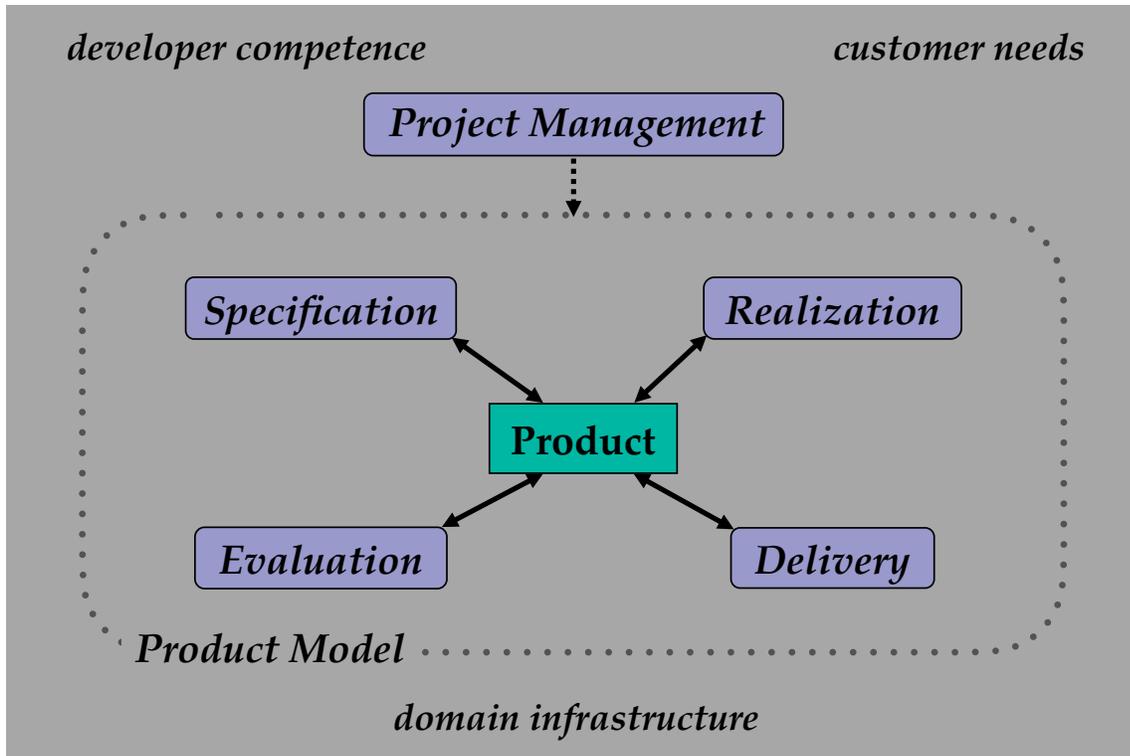


Figure 3.3-1. The DsE Product Manufacturing Project Model

Project Management

The project management element specifies the effort undertaken to build a product customized to meet the changing needs of a designated customer (or simple market). This element is a variant of the project management element as described in section 2.2, adapted to the use of provided domain capabilities to build a product model.

The project management element specifies:

- Project direction (the organization, resources, and developmental guidance applied in performing the domain-specified product manufacturing process)
- Product planning (the customer relationship and product master plan for building the product model for a responsively changing product)
- Increment performance (the planned performance of tasking that results in baselined versions of the envisioned product model)

The project management element is reviewed relative to the project's productivity and resulting product quality to identify unmet project needs and possible improvements in

provided domain capabilities. Project management participates in domain-orchestrated collaborations among related projects on prioritization and resourcing of planned domain tasking.

Product Specification

The product specification element specifies the resolution of deferred decisions that describe the product that can be built to best meet a customer's specific needs. The domain-provided manufacturing infrastructure identifies how differences in buildable products have been expressed as deferred decisions and how these can be resolved to describe an envisioned product. These decisions are resolved in collaboration with the customer to specify one or more candidate versions of the product. These candidates can then be comparatively evaluated and iteratively refined, to obtain the most viable fit to customer needs for deployment into operational use.

The product specification element is augmented, for reference by developers as customer needs and domain capabilities change over time, with:

- Characterizations of uncertainties and tradeoffs that have motivated evaluation of alternatives and the criteria and rationale for how these have then been resolved
- Limitations in resolving deferred decisions or deficiencies in the product family as currently supported that preclude a better approximate fit to the customer's needs, which are referred back to domain engineering for future consideration

Product Realization

The product realization element specifies how the elements of a product model corresponding to a (partial or complete) product specification are derived. Derived elements are customized based on the application of relevant deferred decision resolutions to corresponding content of the domain-provided product family. Multiple product versions can be derived for direct comparative evaluations of their differences in behavioral capability or qualitative criteria. If some decisions have not been fully resolved, it may be possible to derive a "partial" product having limited capabilities or reduced quality. A realized version of a product may include instrumentation that supports monitoring, control, and analysis of product behavior.

The product realization element is augmented with:

- The quality factors that can be projected as characteristic of each realized candidate product version
- Any permitted developer-provided content that compensates for recognized limitations in domain capabilities
- Emulated devices injected into candidate product versions to support product evaluations in virtualized environments

Product Evaluation

The product evaluation element specifies (1) the validation of a product specification as consistent with customer acceptance criteria (i.e., perceived needs and constraints) and (2) the verification of a product realization (i.e., its content and behavior) as consistent with its corresponding product specification. This element is augmented with reviews of product model content by subject matter experts, analyses of experimental results of the use of derived operational scenarios, and analyses of experimental results, as enabled by domain-provided capabilities for performing empirical and analytical evaluations. This element may provide for the customization of scenarios to reflect differences in operational circumstances beyond the content of the product specification.

A scenario encompasses specification of purpose and expected results, initialization of the operational context, interactions with entities (represented devices, users, and systems) to acquire results, and analysis of results against expectations. Scenarios are provided as part of the product family model, in the customer needs element of the specification-derived product model.

The evaluation element may identify not only defects in the product specification but also defects in the domain, either in the definition of the product family or in the specified manufacturing process (e.g., misapplication of decisions, missing decisions, or flaws in the content of the product family model). Domain defects are recognized as inconsistencies in validation or verification that cannot be corrected by changes in the product specification.

The product evaluation element specifies the degree to which a derived product meets customer expectations in terms of:

- The degree to which a product specification is agreed, based on reviews by subject matter experts, to be a proper expression of perceived customer needs and any discrepancies
- The correlation for scenarios of actual to expected results
- The correlation of product behavior, based on dynamically collected data and associated empirical analyses of this data, to relevant quality measures, determining the degree to which quality criteria are anecdotally satisfied
- Analyses that indicate the degree to which a product model is a consistent and complete realization of its originating product specification
- Comparative analyses of the results acquired in evaluating alternative candidate products, according to differences in their respective decision resolutions
- Tracing of any discrepancies in product behavior to the product specification or other product model content

Product Delivery

The product delivery element specifies the orchestration and results for the deployment and support of a product to the customer. The delivery element consists of a definition of the deployed product indicating its originating domain version and its product specification and feedback on customer acceptance and usage of the product, including identified deficiencies (both defects and any divergences from actual needs), potential improvements for current needs, and anticipated changes in needs or operational circumstances.

The delivered product includes product model elements that prescribe:

- Characterization of the customer operational environments in which the product can be used
- Customer acceptance criteria and preparations required for transition to operational use of the product
- Materials that support customer acceptance (installation, validation, and certification) of the product for operational use

- Materials that support operational use of the deployed product (logistical support and documentation of training and assistance to be provided to customer personnel for the proper use of the product)

A Simplified View of the Product Manufacturing Workflow

The essence of the product manufacturing workflow is the expeditious development of a product model for a high-quality product that fits the needs of the project's customer [Figure 3.3-2]. A product specification is applied to the product family to create a product model that expresses a product customized to the needs of a specific customer. The product specification is characterized by a domain-specific representation of the deferred decisions that distinguish among the buildable-instances of the product family. The appropriate elements of the derived product model are extracted as a product for delivery to the project's customer.

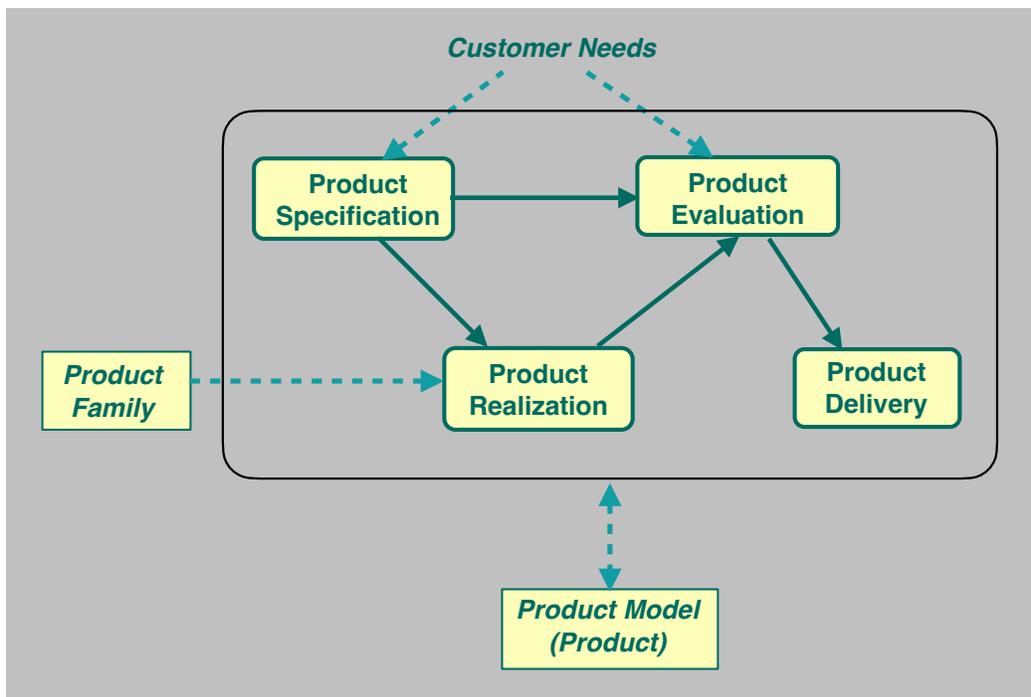


Figure 3.3-2. A Simplified Product Manufacturing Workflow

Advanced Considerations

Just as DsE supports building customized products for multiple customers having similar needs, it also supports building multiple versions of a product for each customer: (1) multiple interim versions that support resolving uncertainties and

tradeoffs to determine the version that is the closest fit to perceived actual needs, (2) alternative versions that best fit a customer's needs in each of multiple differing operational contexts, and (3) revisions of an existing product over time as needs change.

Since only few instances of a conceptually complete product family may initially need to be built, the manufacturing capability may be initially developed to support building only instances of a subfamily that includes currently needed products. This capability can then be incrementally extended over time as different needs emerge. In the conception of a product family, it will encompass products that will not be feasible to build without further domain engineering effort. The preferred option in the case of an instance that cannot be easily built is to negotiate changes in the customer's expressed needs so that a close approximation can be built and deployed into initial use.

Subsequent domain engineering effort can be requested to extend domain capabilities so as to better support that customer's unmet needs.

The product realization element is conceived as being a fully automated derivation of a product but there will be cases of needed domain capabilities not having been fully developed. In anticipation of such cases, domain engineering may provide for limited manual developer involvement as part of the product specification element. Manual actions would take the form, for example, of manually selecting and customizing product family assets based on resolved decisions, of injecting special-purpose code for incorrectly derived or ancillary functionality, or as annotations regarding expectations or limitations related to unresolved uncertainties. In most cases, manual variances should be avoided, as these can complicate derivation of a revised product by requiring effort to replicate the manually developed content, further inhibiting future product improvements. Instead, unsupported capabilities should be given due consideration for inclusion in a domain revision.

{discuss concurrent nature of product manufacturing tasking including exploration of differing product specifications for comparative evaluations of problem-solution alternatives (see same in 2.0)}

{here or somewhere in 3.4 explain how unresolved decisions can support derivation of alternative product models}