

3.3 DsE Product Manufacturing

Product manufacturing, as the “manufacturing” component 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. 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 rapidly provide a revised product that reflects those changes.

Product manufacturing is performed within the framework of a domain as specified by DsE domain engineering for a targeted market. The domain defines a product family and an associated manufacturing process for the resolution of deferred decisions that specify a customized product instance for the customer. The defined process can differ depending on a program’s business and market concerns, varying to account for potential differences in customer-imposed constraints.

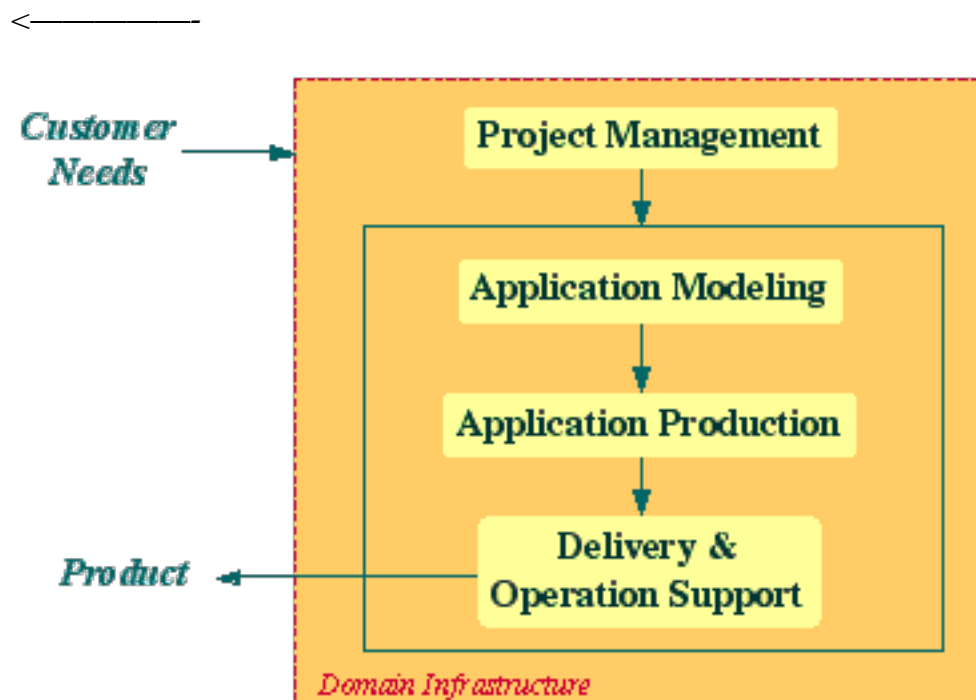


Figure 3.3-1a. An Idealized Product Manufacturing Process

Figure 3.3-1b. A Transitional Product Manufacturing Process

Conceptually, product manufacturing has five elements [Figures 3.3-1]: project management, product specification, product realization, product evaluation, and product delivery. (Its actual formulation within a DsE program is determined and further elaborated in the process engineering element of domain engineering.)

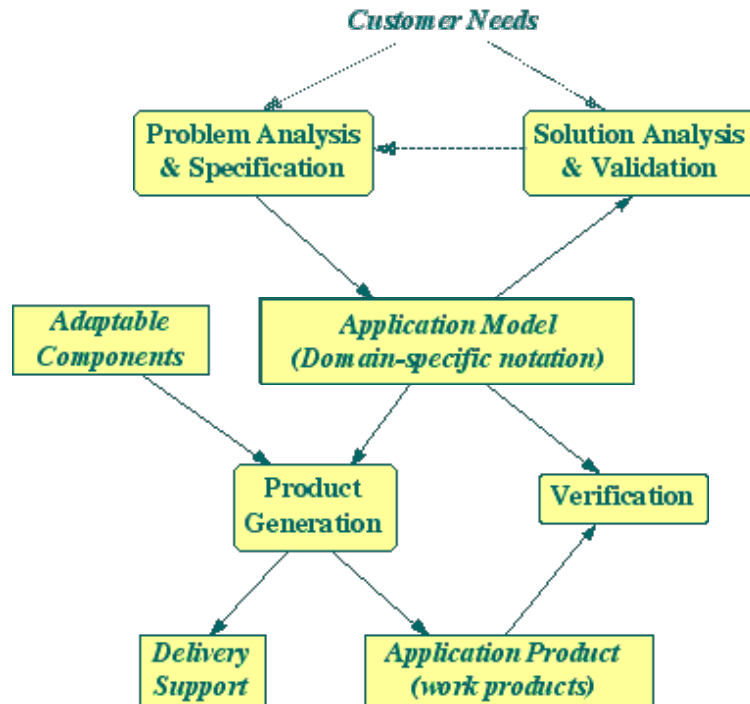


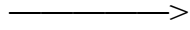
Figure 3.3-1b. Notional Steps for Product Specification, Realization, and Evaluation

{The domain defined by the DsE Domain Engineering includes the specification of a specific product manufacturing process, along with a product family from which products are derived. The purpose of this section is only to describe the general nature of any DE-defined process. The actual process to be followed will be designed to suit the needs of projects building products for customers in the market targeted by the domain.}

product specification (product family) -> product model -> product

A product is a realization of a problem and solution as viewed in the context of a market-associated product family.

The product manufacturing process is a condensation of the DsE-extended basic software product engineering process. The result of this process is a project management model and a product model that is a refinement of a model that specifies the product family.



Project Management

(see section 2.2; includes customer relationship/sales)

The purpose of the project management element is to define the organization and operation of a project to build a customized product for a designated customer (or simple market).

The project management element specifies:

- how the project is organized and resources assigned to perform the domain-specified product manufacturing process
- interactions that occur with the customer to specify and build a product responsive to their needs
- the ways in which the provided manufacturing environment and associated assets have enabled or limited building a suitable product
- evaluations of project efforts, relative to process and product quality and customer feedback, characterizing future needs for product evolution including feedback on domain engineering capability improvements for project needs

Product Specification

The purpose of the product specification element is to resolve the uncertainties concerning a particular product that can be built to best meet the customer's specific needs. These uncertainties distinguish the derivable instances of a product family and are expressed in terms of a set of deferred decisions. These decisions are resolved in

collaboration with the customer to derive one or more candidate products for evaluation, refinement, and subsequent deployment into operational use.

The product specification element specifies:

- One or more, partial or complete, candidate resolutions of domain-specified deferred decisions that reduce the candidate set of products to those that should be an approximate fit to the customer's needs
- Content of statically derivable elements of the product model corresponding to each candidate resolution of deferred decisions
- The quality factors that can be projected as characteristic of each specified candidate product
- Criteria resulting from comparative analyses of alternative products that reduce the candidate set, including (1) any limitations on decisions or resolution thereof that prevent specifying a product that more closely fits a customer's actual needs, (2) any deficiencies (e.g., incompleteness) in the product family as currently defined for which some candidate resolution of deferred decisions corresponds to a product that cannot be built, and (3) how issues were resolved or referred back to domain engineering for consideration

Candidate resolutions of deferred decisions are determined through a collaborative dialog with the customer, including refinements based on reviews of the derived customer needs element (and others as needed) of each derived product model.

Alternative resolutions of deferred decisions are supported for when there is uncertainty as to how to resolve some decisions; the resulting alternative products can then be comparatively evaluated in terms of their corresponding derived product models.

Product Realization

The purpose of product realization is to generate one or more selectively instrumented candidate versions of an envisioned product as determined in the product specification. It may be possible to derive a partial product, having limited capabilities or reduced

quality, if decisions have not been fully resolved. Alternative products generated are subjected to a comparative evaluation based on needed capabilities and quality criteria.

The product realization element specifies

- the application of resolved decisions to the selection, configuration, and composition of domain elements to realize a customized product model and built product
- instrumentation injected in building a candidate product to support evaluating the product's fit to customer needs and quality criteria and tradeoffs
- derivation, for purposes of comparative evaluation, of multiple candidate products based on uncertainties reflected in alternative or incomplete decision resolutions
- expert reviews of a derived product model as to consistency and completeness given its product specification, and for conformance of the built product to the product model

Product Evaluation

The primary purpose of the product evaluation element is to determine that the product specification is consistent with customer needs as understood and that the behavior of the derived product is consistent with that specification. Also essential but incidental to this purpose, evaluation may expose defects in the domain either in the application of resolved decisions or in the definition of the product family. It may also indirectly expose flaws or needed improvements in the domain-provided manufacturing process.

- feedback to domain engineering on defects in the product due to misapplication of decisions, missing decisions, or in common aspects of the product model or product

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

- selection and derivation of customized product evaluation scenarios, including data initialization, based on understanding of customer needs expressed in

resolved decisions used to derive the product and any additional decisions that customize the scope of activity that a given scenario concerns

- dynamically collected data representing product behavior and associated empirical analyses of this data to predict relevant quality measures to evaluate degree to which quality criteria is being anecdotally satisfied
- verification results that indicate the degree to which a built product is a consistent and complete realization of its associated product specification
- comparative analyses of the results acquired in evaluating alternative candidate derived products, organized according to differences in their respective decision resolutions
- how any discrepancies in product behavior trace to content of derived product model elements (i.e. reflecting inconsistencies in the derived product model)

A scenario encompasses specification of purpose and expected results, initialization of the (virtual or hybrid) operational environment, interactions with entities (represented devices, users, and systems) to acquire results, and analysis of results against expectations. Scenarios may be provided by the product family, by the customer needs element of the product model, or created within this element as a potential future extension to scenarios provided by the product family.

Product Delivery

The purpose of the product delivery element is to orchestrate the deployment and support of a product with its designated customer.

The product delivery element specifies

- a deployment specification describing a deployed product indicating its originating domain version and its product specification (used to derive the product model and associated product)
- an environment specification describing the details of its operational environment (redundant: included in its product model)

- an installation specification (also in the derived product model)
- supported efforts for customer validation and certification of the product against associated acceptance criteria as specified
- documentation of training and assistance provided to customer personnel in the proper use of the product
- feedback on customer usage, including any identified deficiencies (including defects or other divergences from actual needs), potential improvements for current needs, and anticipated changes in needs or operational circumstances

Additional Considerations

Just as DsE supports building customized products for different customers, 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 its different operational contexts, and (3) revisions of an existing product over time as needs change.

Since only few instances of a conceptually complete product family will initially need to be built, the manufacturing capability may have been developed to support initially building only instances of a subfamily that includes currently needed products, to be incrementally extended over time. 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. Subsequently, domain engineering can be requested to extend the domain so as to better support the 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 inhibit future product improvements, in lieu of being given due consideration for inclusion in a subsequent domain revision.