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 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 a condensed realization of the basic software product engineering process limited to building instances of the product family. The result of performing this process is a product model for a product that addresses a customer's particular needs.

{This section describes only the general nature of DsE product manufacturing. The process engineering model defines the actual formulation of the project model and associated manufacturing process to be followed by projects building products for customers in the program-targeted market. The defined process can differ depending on a program's business and market concerns, varying to account for potential differences in customer-imposed constraints.}

Conceptually, the product manufacturing project model has five elements [Figure 3.3-1]: project management, product specification, product realization, product evaluation, and product delivery.

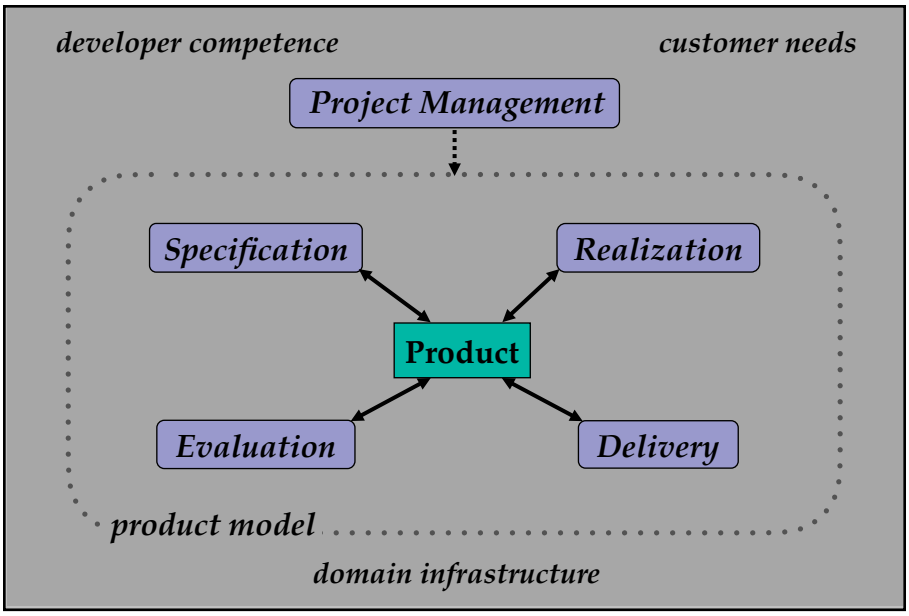

Figure 3.3-1. The DsE Product Manufacturing Project Model

{discuss concurrent nature of product manufacturing tasking (see same in 2.0)}

<————————-

revise figures and terminology in terms of the 5 project model elements

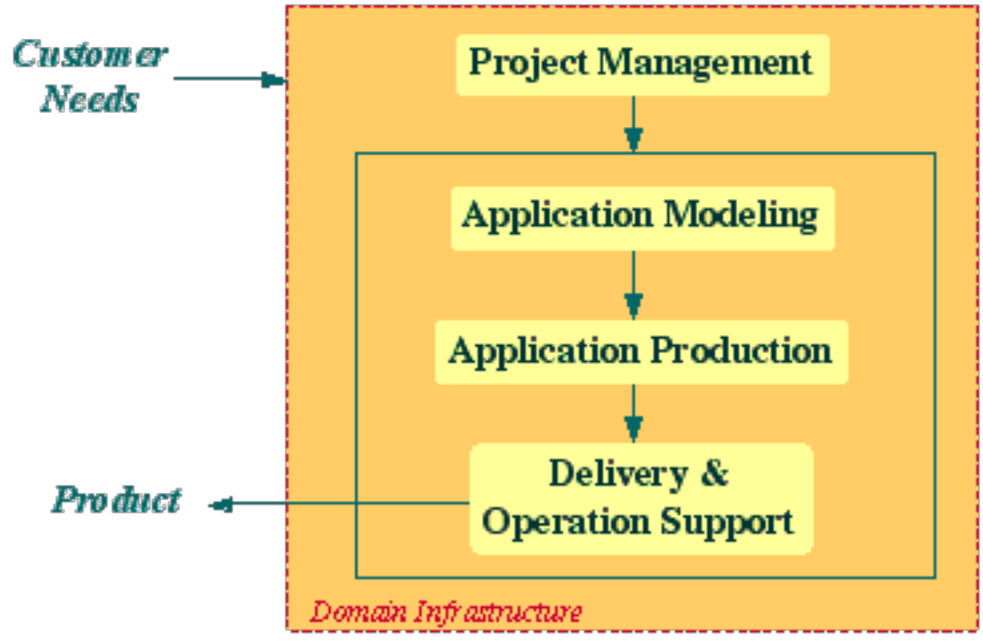

Figure 3.3-2a. An Idealized Product Manufacturing Process

Figure 3.3-2b. A Transitional Product Manufacturing Process

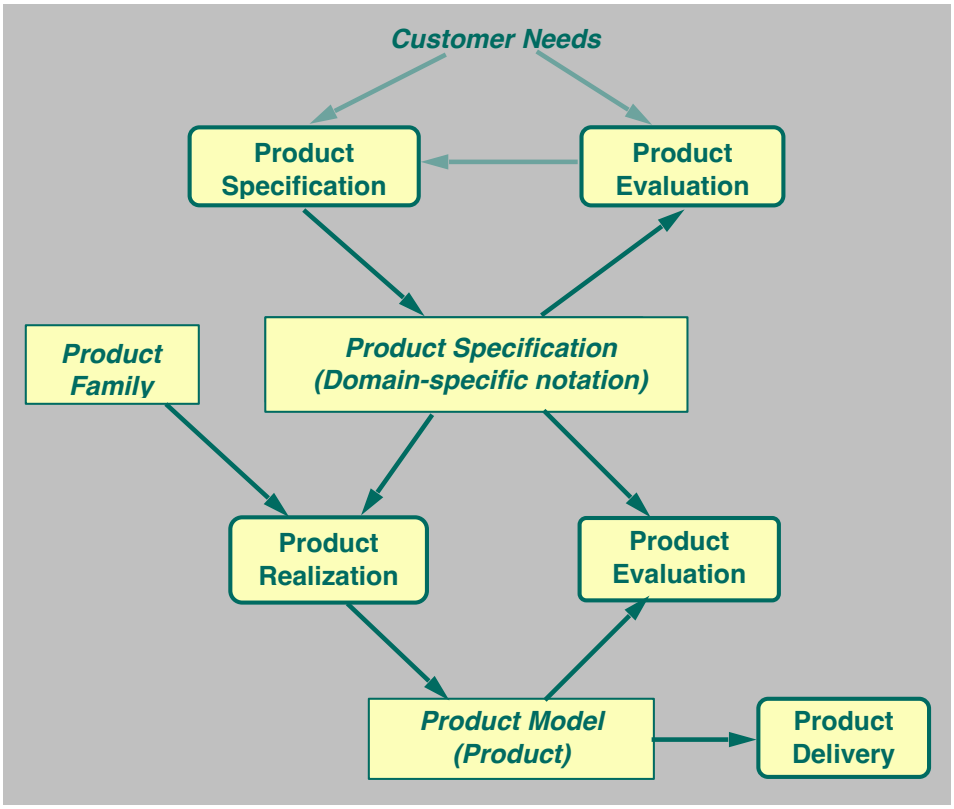

Figure 3.3-3. Notional Relationships in DsE Product Manufacturing

————————>

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 of the project model (as described in chapter 2), adapted to the use of provided domain capabilities to build a DsE 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 for productivity and product quality to identify prospective project needs and on-going 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 uncertainties concerning the product that can best be built to meet the customer's specific needs. The domain-provided infrastructure identifies how uncertainties have been expressed as deferred decisions and how these can be resolved, determining which particular instances of the product family can be derived. These decisions are resolved in collaboration with the customer to specify one or more candidate versions of the product specification to be iteratively evaluated, refined, and realized in product form for deployment into operational use.

The product specification element specifies:

- Candidate resolutions of deferred decisions that reduce the candidate set of products to those that should be an approximate fit to the customer's needs
- Issues, tradeoffs, and rationale associated with decision resolutions
- 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 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 application of relevant deferred decision resolutions to corresponding elements of the domain-provided product family. A realized version of the product model may include selective instrumentation that supports monitoring, control, or analysis of product behavior or ancillary content *(such as documentation, experimental data initialization, emulated devices, ...?)*.

A partial product will have limited capabilities or reduced quality if some decisions have not been fully resolved. Multiple product versions can be derived for direct comparative evaluations of their differences in behavioral capability or qualitative criteria.

The product realization element specifies:

- The application of (partially) resolved decisions to the selection, configuration, and composition of domain elements to realize one or more customized product model versions
- 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
- Concrete realizations for incomplete domain elements of a derived product model.
- Instrumentation injected into a candidate product version to support evaluating its fit to customer needs and quality criteria and tradeoffs

Product Evaluation

The product evaluation element specifies (1) the validation of a product specification as consistent with customer acceptance criteria (i.e., needs as understood) and (2) the verification of a product realization (i.e., its content and behavior) as consistent with its corresponding product specification. This element includes the specification of experimental scenarios, operational environment customization, and analyses of experimental results, as enabled by domain-provided means for performing evaluations.

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.

Secondarily, the evaluation element may identify 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 common aspects of the product model or product). Such defects are expressed as inconsistencies in validation or verification that cannot be corrected by changes in product model content.

The product evaluation element specifies the degree to which a derived product meets customer 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
- 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
- How any discrepancies in product behavior trace to content of derived product model elements (i.e. reflecting inconsistencies in the derived product model)

Product Delivery

The product delivery element specifies the orchestration for the deployment and support of a product with its customer.

The product delivery element specifies:

- A deployment specification describing a deployed product indicating its originating domain version and its product specification (and its corresponding product model)
- Elements of the product model that support deployment (specifications for the product environment, product installation, product validation and certification)

- Elements of the product model for operational use of the deployed product (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 initially developed to support 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.