

2.8 Product Verification

The product verification model specifies substantiation that all product model element instances and the product model as a whole are consistent and logically complete and that the resulting product is a proper realization of the product model¹. If discrepancies are identified, these are referred to the relevant elements of the product model for resolution. This model has five elements: directed reviews, applied analytics, normative testing, anomaly testing, and regression testing. These elements capture the evaluation criteria and results obtained using associated techniques.

Consistency is a pair-wise evaluation of all elements of the product model to identify differences due to changes and discrepancies between them that need to be reconciled. These evaluations occur when authors of related element specifications have baselined versions that are intended to be consistent.

Completeness is a determination that the product model is a sufficient basis for realizing a version of the product that can be empirically evaluated as to its value (utility and quality) in its actual ecosystem. Completeness is further a determination of the degree to which the product as a derivative of the product model provides a “true” realization of the capabilities specified in the product requirements model. This evaluation depends on the deployable product element of a baselined product delivery model and its associated baselined product requirements model.

The product verification model is the basis for determining whether a realized product version meets both customer acceptance criteria and project developmental quality criteria. To this end, the product requirements and product environment models must be consistent with the customer needs specification and all other elements of the product model must be mutually consistent with those.

¹ Based in part on *An Acquisition Perspective on Product Evaluation* (CMU/SEI-2011-TN-007), CMU Software Engineering Institute, Pittsburgh, PA, Oct 2011.

Product Model Reviews

(product model completeness review: evaluate degree to which model element reviews have been properly completed and identified critical issues satisfactorily resolved such that all dependent elements are consistent)

The directed reviews element specifies the results of developer-directed peer and expert reviews in determining the consistency and completeness of all product model elements. A part of this specification is developed for each product model element. Each element is repeatedly reviewed based on its developer's need for evaluation of and alternative viewpoints about how uncertainties, inconsistencies, and tradeoffs within and among product model elements are most equitably resolved.

Consistency of a product model is consistency of all specification-realization dependencies among its elements. Product element versions may be inconsistent while some are undergoing change in keeping with an increment plan. Both specifications and realizations may be iteratively modified within an increment, with an objective of consistency, even if completeness for a product release requires multiple increments to achieve.

Applied Analytics

The applied analytics element specifies the results of applying static and dynamic analytic evaluations to qualities that can be inferred from the product model or exhibited in the behavior of the resulting product.

derived metrics (eg from testing-supplied measurements)

predicted properties

comparative product realizations (evaluating relative product value for alternative product models)

Normative Testing

The scenario testing element specifies the correspondence observed between the product model as specified and the behavior exhibited by a corresponding candidate product realization. This correspondence is the result of scenario-based operation of a

product realization to obtain a comparison between expected and observed results for a specified testing event. The product model considered may be limited to any subset of the envisioned product (i.e., an assembly of related components) sufficient to perform a specified scenario.

Testing Platform

A testing platform is any mix as needed of all or parts of the actual or approximated product ecosystem, as specified in the product environment model, along with capabilities for instrumented monitoring and control of a testing event. Instrumentation includes the means to inject data and collect, retain, and report resulting computational results. A product is deployed into a testing platform in a form equivalent to that for its actual operational environment.

(creating a testing infrastructure; oper env defn; instrumentation mechanics; data collection-reporting; logging/data capture) (family of testing platforms or testing events?)

Testing Events

A testing event occurs on a testing platform with a subject of any component assembly. A component assembly is a subset of a baselined product instance, one or more components being verified along with any other supporting components needed to make the set as a whole operable within the testing platform. A product instance is derived as specified in the product delivery model, again to be operable within the product operational environment.

At all of these levels, the behaviors of the environment and any needed external elements may be simulated and any needed devices that are elements of the product may be emulated unless they are physically accessible. The product and any simulated or emulated elements may be instrumented to artificially control behavior and provide observability into the causes and effects of that behavior.

Verification involves three stages: preparation, execution, and analyses of results. Preparation is the plan and set up for a testing event. This entails an objective, customer-based or freeform scenario, a guide/playbook, testing platform set up including data initialization scripts, and expected results. Execution is the manual and /

or automated performance record of a planned testing event (automated, directed, or device/user-role portrayal), including results of monitoring and control actions and collected data on behavior. Analyses of results correlates testing event occurrence to planned noting any divergences from expected with suspected cause and any remediative or diagnostic actions recommended for either the test event or its subject. Reporting should include results of any analytic evaluations of the testing event or resulting data.

Evaluation Criteria

The product requirements model defines the behavior that a resulting product is expected to exhibit. This model is defined to be consistent with the customer needs element of the product delivery model. The plan for a testing event will identify how its expected results are related to expected product behavior as whole, recognizing that a particular testing event may concern only a limited aspect of specified behavior.

Scenario Specifications

A primary basis for testing events is the set of operational scenarios defined in the product documentation element of the product delivery model. A scenario is specified in a form that provides sufficient information (preconditions, actions, and expected effects) to allow it to be performed (manually or automated as appropriate) as a testing event. A scenario must define initial conditions and data for testing platform initialization and correct observable behavior that should result. Results include any interactions that are expected to occur between the product and any entities in its operating environment, as defined in the product environment model, and consequent effects on associated data. Scenarios should be conceived both to confirm occurrence of expected behavior and detect occurrence of unexpected behavior (e.g., due to invalid data values or as unforeseen effects of proper behavior).

Anomaly Testing

The anomaly testing element specifies An anomaly test is a dynamic evaluation that (1) the product behaves correctly under conditions of failure (e.g., of a device) or fault

(i.e., of the product to operate correctly in response to failure), or (2) that the product does not accommodate any excluded or unspecified conditions.

Regression Testing

The regression testing element specifies Regression testing is repetition of prior normative and anomaly testing on aspects of product operation that are nominally unchanged and therefore should produce identical results to such past testing. A regression test is a dynamic evaluation that a candidate product produces the identical behavior with a prior test of the same or derivative product. A test that fails to produce the same behavior indicates that the product has been modified relative to the specification of the test; this indicates the need to revise either an intervening modification to the product or the test specification so that the two are again consistent.