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Requirement Specification

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Synonyms

Constraints; Demands; Functional specifications; Technical specifications

Definition

In the (mechanical) design process, the requirement specification is a formal registration of the conditions that are imposed on a new or altered product design, both preceding as well as during the corresponding product development cycle.

Theory and Application

In product development cycles, stakeholders constantly deliberate about alternative solutions to design problems. This observation stresses the importance of decision-making processes for the overall effectiveness and efficiency. Requirement specifications serve as a reference for judging the available decision alternatives. As such, they have a large impact on the course of development cycles (Gottesdiener 2009).

In engineering, a requirement is a singular documented need of what a particular product or service should be or perform. It is most commonly used in a formal sense in systems engineering, software engineering, or enterprise engineering. It is a statement that identifies a necessary attribute, capability, characteristic, or quality of a system in order for it to have value and utility to a user.

In the classical engineering approach, sets of requirements are used as inputs into the design stages of product development. Requirements are also an important input into the verification process, since tests should trace back to specific requirements. Requirements show what elements and functions are necessary for the particular project.

The requirement development phase may have been preceded by a feasibility study or a conceptual analysis phase of the project. The requirement phase may be broken down into requirement elicitation (gathering, understanding, reviewing, and articulating the needs of the stakeholders), analysis (checking for consistency and completeness), specification (documenting the requirements), and validation (making sure the specified requirements are correct).

Product development comprises of the processes that transform the needs of the customer or the marketplace into a product that satisfies

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these needs. In general, it is a process conducted by designers and engineers, involving many other stakeholders. Although the composition of such product development teams may seem rather intangible, usually there are clear (though possibly implicit) motives to bring together the expertise and domain knowledge of the people involved. Within the context of the organization, the customer (type), the type of product to be developed, and the development team can address the specified need by means of an agreed upon design method.

When decisions are considered instigators of the development process, the nature of the available context for taking a decision becomes increasingly important. The requirement specification can serve as a frame of reference through the entire development cycle and as such is an indispensable part of that context. Throughout the development cycle, the subject of the decisions will change with respect to level of detail, level of aggregation, considered domains, etc. To support a well-substantiated decision, the expression of the requirement specification must ally with the characteristics of the decision at hand. As a structure for the alliance, three types of requirement specification can be discerned: technical specifications, functional specifications, and scenario-based specifications (Lutters and Ten Klooster 2008).

Stated Purpose

All specification types comply with the stated purpose of the development process, which is a predefined, formalized, and static reference of that development process. Therefore, the stated purpose reflects the pre-imposed requirements of (external) stakeholders, like law, marketing, and safety. Due to its static nature, this type of reference hardly influences the selection and use of the different requirement types.

Specification Types

Technical Specifications

Technical specifications are complete and unequivocal expressions of product requirements. They address, e.g., the minimum wall thickness of a beer bottle, the power to weight ratio of a motorcycle, or the nominal size plus tolerance of a shaft in a subassembly. In general, technical specifications express quantitative or easily quantifiable demands.

Functional Specifications

Functional specifications provide a description of desired future product behavior. In general, they express concrete demands to abstract product models. As an example of functional specifications, consider a beer bottle falling of a table. The bottle is required to stay intact after the fall.

Scenario-Based Specifications

In product specifications based on scenarios, emphasis is being placed on the product's environment and the interaction between product and its environment. Product behavior is indicated in terms of what the environment, e.g., the user, can do with a product and how it will interact as opposed to technical or functional specifications where, traditionally, focus is placed on what the product will do and how it does it (Miedema et al. 2007).

Compound Requirement Specification

The solution space in which product development processes are allowed to take place is determined by the frame of reference. The specifications constituting the frame serve as an argumentation and negotiation basis for taking design decisions. In many cases, the specifications will be clear and unambiguous. However, especially in the early stages of a development trajectory, they can be uncertain, incomplete, and even contradicting. In order not to introduce feint certainties in the process, it is important to adequately represent specifications applicable to a certain decision.

Dynamic Requirement Specification

When the frame of reference is constituted by evolving requirement specifications, the relations between the specifications must be dynamic as well. The product definition will concurrently evolve on different levels of aggregation, instigated by different viewpoints, and with respect to different aspects. For the requirement specification to serve as a reference in the entire solution space, it must therefore be possible to interrelate the information constituting the different specification types.

Application

In the (mechanical) design process, the requirement specification is a formal registration of the conditions that are imposed on a new or altered product design, both preceding and during the corresponding product development cycle. For a long time, the use of technical specifications has prevailed in the establishment of such requirement specifications. However, gradually, there is an appreciation for the fact that sheer technical specifications may inadvertently fix constraints and possibilities too early in the process. Moreover, it is recognized that technical specifications are unsuitable to adequately address the role of unquantifiable aspects that play important roles in the development cycle. Using functional specifications and scenarios may aid in addressing these problems.

Application in Development Cycles

In development cycles, two types of phases can be distinguished: diverging and converging phases. Due to their different natures, the phases require different support methods to establish increased process effectiveness and efficiency.

In diverging phases, adequate support facilitates the generation and evaluation of explicit product information from abstract ideas. A dedicated work environment for performing product development tasks can offer such support by assessing a design in different contexts. These environments are called synthetic environments. In synthetic environments, the use of a.o. media and virtual reality techniques triggers the use of the associative capacities of the stakeholders involved in the performance of the task. They therefore allow development activities based on aggregate influence factors.

For this support to be beneficial to the effectiveness and efficiency of the design process, the synthetic environments must use an explicit but not necessarily decomposed representation of the requirements for reflecting new ideas within the boundaries of the stated purpose. In a synthetic environment, technical and functional requirements are not enough to attain oversight in the early phases. They also do not give much insight in the interrelations and reasons for existence of certain requirements. Typically, scenario-based requirement specifications therefore have the added value to let stakeholders, regardless of their disciplinary background, experience the aggregated quality of their ideas.

In later stages of the development cycle, the divergent product information must be combined in one coherent product model. This process generally requires much iteration; the many, often conflicting, product properties must be brought in harmony, but a change in one aspect induces consequences for the validity of the model with respect to another aspect. In the so-called what-if design method, these relations are modeled explicitly. This allows an automatically generated overview of the possible consequences of a design change. A condition for this type of support to be implemented is that the functional and technical specifications within which changes are allowed are modeled adequately. Moreover, in order to warrant the significance of the product model for the stated purpose of the development process, the modeling must be in harmony with the more general picture of the requirements as agreed upon in previous stages of the design process. This observation stresses the importance of a coherent frame of reference for the entire design process that can be viewed from different perspectives, depending on the need for a specific representation.

Cross-References

- ▶ Product Development
- ▶ Virtual Reality
- ▶ What-if Design

References

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