

# Balancing Manufacturability and Performance Attributes in Lean Design

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## ABSTRACT

Implementing the Voice of the customer is one of the main challenges during the Vehicle Development Process. The variety of desired vehicle attributes requires well-defined processes that include manufacturability along with the voice of the customer in all aspects of the product development process. Customer's defined attributes along with regulations and manufacturability requirements should flow through all process phases starting from the early concept development phase.

This paper discusses a lean design approach to assure that the voice of the customer attributes are addressed and balanced through the product development process from concept to production. The lean approach includes architectural, performance, and manufacturability as key development attributes. A case study of Automotive Modular Door System is presented to demonstrate the application of the lean approach in the design and development of complex automotive systems. In this case study safety and manufacturability are considered as the key attributes shaping the system.

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## INTRODUCTION

To meet customers' demands vehicle manufacturers need lean processes that include the voice of the customer in all aspects of the Product Development Process. While lean thinking has propelled the movement of the auto industry from mass to lean production [1,2], lean design efforts have been limited and focused on directing the design activities to enable lean manufacturing, cost reduction, or management of the traditional design process [3,4]. An effort towards the implementation of lean principles to reshape the design process itself was introduced [5]. This effort did not address the identification of the lean principles with the different phases of the Product Development Process or how to deal with conflicting product attributes.

In traditional design processes, the focus is on achieving and validating individual attributes, rather than the whole set of product attributes and constraints simultaneously. This usually results in a segmented process with several iterations and rework [6]. As for the resulting product, focusing on one attribute at a time prevents the full optimization of the product as a whole. To produce a balanced and optimized product that meets customers' needs, a well-defined design process that includes all other development attributes simultaneously is necessary. The key factor in this process is to consider the variety of customers' attributes in addition to manufacturability and regulations' requirements from concept

development to production. In the following, a lean design process is developed to assure the full flow of all product attributes and constraints from early phases. A lean principle is identified with each specific phase of this design process. In addition, the flow of performance and development attributes through the process is discussed and demonstrated through an automotive door case study.

## LEAN PHASES OF THE DESIGN PROCESS

A product development process with three main phases of inception, conception, and development is discussed in reference [7]. While the lean principles need to be applied at all three design phases to achieve a true lean design process, each principle can be mostly aligned with specific design phase or sub-phase as shown in Figure 1.

In general the five lean principles can be identified with the design and development phases as follows:

- Value - can be mostly identified and specified from the customers' perspective during the inception design phase.
- Value Stream - Can be mostly achieved during the concept and product specification phase guiding all the steps along the process chain.

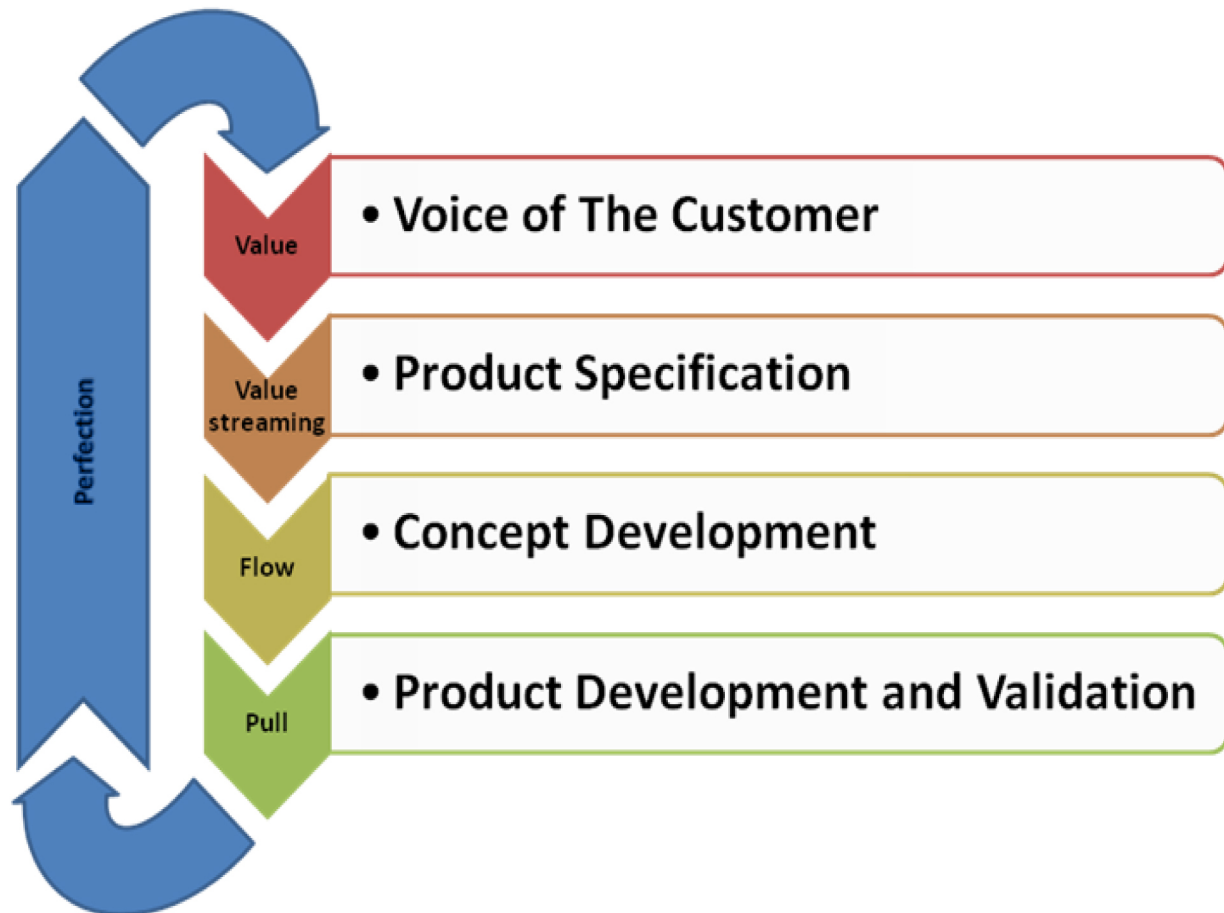


**Figure 1. Lean Design Process**

- Flow - Value process flow starts with features and attributes shaping the product at the concept development phase.
- Pull - During the product development and validation phase the features and attributes needed by the customer are assured based on the customers' demand.
- Perfection - During all phases and redesign strive for perfection by continually attempting to produce exactly what the customer wants.

During the inception phase, the product definition starts with the voice of the customer which is usually expressed in the form of product attributes such as safety, durability, reliability, affordability, etc. These attributes as defined by the customer should be the drivers for all product key attributes as shown in [Figure 2](#).

The customers' defined key product attributes in addition to all regulation and development constraints are combined to form the full set of product attributes. These product attributes must then be specified by identifying the set of engineering design criteria for each attribute [5].

After identifying the design criteria necessary to achieve each attribute these criteria are then used to set the appropriate design targets for meeting customers' requirements. These design targets form the foundation for the product, subsystems, and components technical specification as shown in [figure 3](#).

The whole set of product characteristics and specifications should flow through the development process starting from the conception phase. This flow starts from the concept specification through concept development and should be assured at concept validation as shown in [Figure 4](#).

Concurrent Engineering is the iterative phase of final product design and development after concept validation and approval. During this development and validation phase all design iterations should be centred on meeting the product specifications set for achieving the product features and attributes desired by the customers until product launch is achieved as shown in [Figure 5](#).

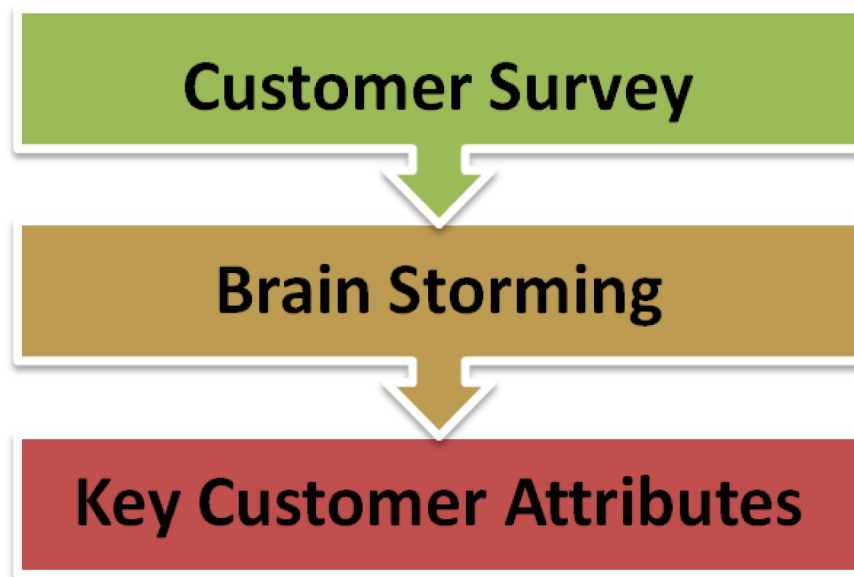


*Figure 2. Voice of the customer*

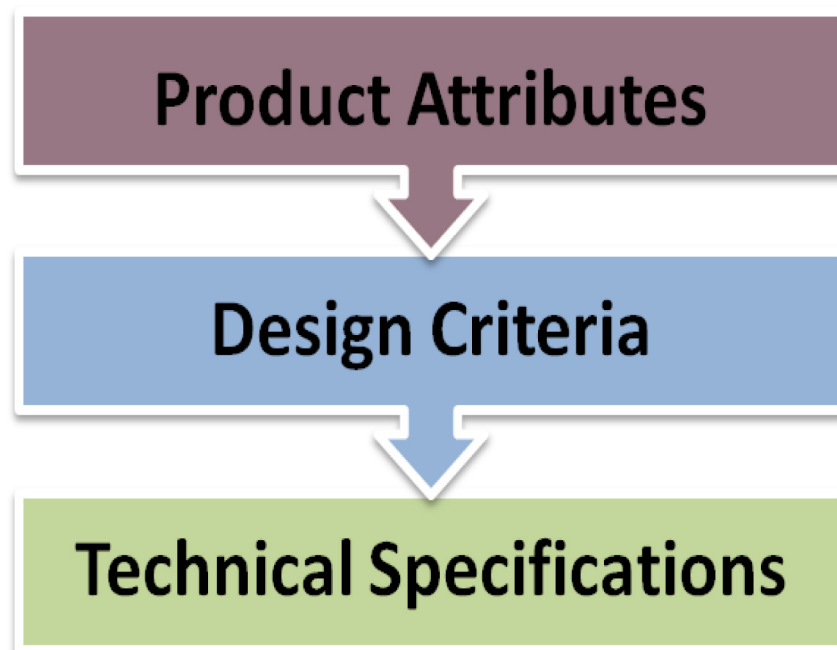


*Figure 3. Product specification*