

Target Setting Principles and Methods in the Product Development Cycle

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ABSTRACT

Vehicle target setting is an evolving process based on continually changing internal (management, standards) and external (competitive and legal) requirements. In addition to evolving requirements, the process for establishing and documenting targets may not be clear. The objective of this paper is to detail the overall process of target setting, the critical factors to consider, and key definitions for each stage of the process. It will describe the complete process from early competitive benchmarking to final verification testing.

Setting targets for a vehicle requires definition and thorough benchmarking of the competition, an understanding of the key attributes used to describe the vehicles' performance, and a clearly defined set of requirements. These requirements will be regulatory, corporate and competitively based and grouped by clearly defined, customer perceived attributes which can be cascaded to specific vehicle systems.

Target setting proceeds following benchmarking and involves iterations of progressing levels of detail as the design matures. Within each design iteration compatibility checks insure that vehicle targets can exist together in harmony with overall program timing and cost constraints. Overlaid with the target setting process is a product development cycle that proceeds from a concept phase through design, prototyping and production verification and validation. This paper will focus on the early phases of a program where targets are primarily set as part of the larger process of vehicle development.

INTRODUCTION

Success in the development of a product involves complete clarity of purpose and consistency in process execution. For products developed by a small team clarity and consistency

can come from a single leader. For simple products less engineering effort is required and the project objective is obvious. In the current marketplace, however, customers desire (and are willing to pay for) highly engineered, highly complex products. In this case the overall customer goal is less than obvious to the product development team members. This paper discusses the structure for turning high-level customer desires into discrete engineering requirements and the disciplined process around requirement management used to deliver highly complex, highly desirable products. This requirement development process will be presented in context as part of the greater overall product development process.

Familiarity with many of the terms used in requirements management may seem helpful but lack of a consistent set of definitions for these terms can easily lead to miscommunication. The George Bernard Shaw reference that "England and America are two countries separated by a common language"¹ reminds us not only that the common definitions of words may differ from location to location but also that their technical definitions can vary as well. It is imperative, therefore, to have a common understanding of these definitions.

- **Requirement:** A measureable characteristic with limits or an optimal value
- **Target:** A quantitative measure of the functional performance necessary to satisfy a requirement
- **Objective:** A Target that has been frozen at a point in the development cycle that the design team is obligated to deliver contractually. Corporate funding is committed as a result of objectives being agreed to.
- **Benchmarking:** To measure (a rival's product) according to specified standards in order to compare with and improve one's own product.

Table 2. Listing of vehicle systems.

Complete Vehicle	Exhaust System
Body System	Fuel System
Frame & Mounting System	Steering System
Engine System	Climate Control System
Suspension System	Electrical Power Supply System
Driveline System	In-Vehicle Entertainment System
Brake System	Lighting System
Transmission System	Electrical Distribution & Electronic Control System

• **Attribute:** A customer-perceived characteristic of a product.

SYSTEM AND FUNCTIONAL DECOMPOSITION

Highly complex products such as vehicles are developed by teams of engineers working on specific parts of the total product which are then integrated together. A consistent and intuitive method of breaking down, or decomposing, the vehicle into logical groupings is critical for this purpose. Two types of decomposition are considered; system and attribute.

The most straightforward breakdown used in the engineering of complex systems is system decomposition; a physical breakdown of the overall product into component parts. Many applications of this type of system can be found in places including the physical cataloging of books via the Dewey Decimal System⁴. This system is made up of ten main classes or categories, each divided into ten secondary classes or subcategories, each having ten subdivisions of its own. The Dewey Decimal top level is shown in Table 1.

Table 1. Dewey Decimal Categories

- 000 – Computer science, information, and general works
- 100 – Philosophy and psychology
- 200 – Religion
- 300 – Social sciences
- 400 – Languages
- 500 – Science and Mathematics
- 600 – Technology and applied science
- 700 – Arts and recreation
- 800 – Literature
- 900 – History and geography and biography

Other examples of system decomposition are found in everything from online shopping to the grocery store (All food, canned food, soups, chicken soup).

Within vehicle design, system decomposition can be utilized to break the product into discrete Systems which can then be broken down in to various Subsystems and Sub-subsystems. Every part of the vehicle has one, and only one, place to go. For automotive applications, the following three tiered system is used⁵. The top level of this system is shown in Table 2.

<table 2 here>

While an important tool, system decomposition does not fully account for all aspects of a product. To consider the full range of customer perceptions we need to use a different classification system. Borrowed from the field of computer and software engineering, the concept of functional decomposition or breaking the overall objective into non-redundant, complementary, smaller units^{2, 3}, is valid for any massively complex engineered product. We use functional decomposition not to describe the discrete parts that go into the product but to describe the complete impression of the product to the customer. Since the customer usually doesn't care what parts make up the final product, we need a type of decomposition that relies on customer terms.

Why is this necessary? For us to be fully focused on the customer, we need to speak in customer terms. We need to set targets based firmly in customer impressions of our product to assure that we make a product desirable to the intended customer. Functional decomposition, therefore, for the purposes of product development is the breaking down of overall customer perception into attributes; specific, direct, customer-perceived characteristics of a product. For any product development application a structure of attributes and perhaps several levels of subattribute are established as a precursor for any target setting or requirement development exercise.

The media and external rating organizations use an implicit attribute structure to evaluate products. As one example, JD Power surveys the public on an ongoing basis regarding experiences and preferences for a range of products. For cars and trucks their survey questions are condensed into a Performance and Design⁶ rating defined in [Table 3](#).

Table 3. JD Power APEAL Rating

Overall Performance and Design: Taken from the Automotive Performance, Execution and Layout (APEAL) study, this measure is based on owner satisfaction with vehicle Performance, Style, Features and Instrument Panel, and Comfort.
Performance: This component of APEAL is based on owner satisfaction with the vehicle's powertrain and suspension systems, including acceleration, fuel economy, handling stability, braking performance, and shift quality.
Comfort: This component of APEAL is based on owner satisfaction with the vehicle's comfort and convenience features and seats.
Features and Instrument Panel: This component of APEAL is based on owner satisfaction with the vehicle's stereo system, gauges/instruments, and heating/air conditioning system.
Style: This component of APEAL is based on owner satisfaction with the vehicle's interior and exterior styling, uniqueness of styling, and exterior and interior colors.

For vehicle development purposes, it is critical to have a comprehensive, standardized set of attribute definitions.

TYPES OF ATTRIBUTES

Independent of the type of consumer product you are designing, there are many general traits that can be described with a common set of characteristics or attributes grouped into the following categories:

- **Appearance** is typically a very subjective measure of the visual appeal of a product. It can vary from person to person and region to region around the globe. Appearance is sometimes referred to as styling and is not uniquely measured for automotive vs. non-automotive applications.
- **Quality** has many facets including how a product looks (materials it is constructed from, fit/finish, etc), feels and its known or perceived durability. Subjectively, it is an attribute, characteristic, or property of a thing or phenomenon that can be observed and interpreted, and may be approximated (quantified) but cannot be objectively measured, such as beauty, feel, flavor, taste. Objectively, it is also a general measure of excellence or state of being free from defects, deficiencies, and significant variations. ISO 9000:2005

standard defines quality as the “degree to which a set of inherent characteristics fulfills requirements.” ¹² Automotive quality is measured primarily in terms of overall durability, fit and finish and materials used.

- **Noise, Vibration and Harshness**, or NVH is a measure of the tactile and audible characteristics of a product. For automotive applications, this is typically a compilation of the three primary components of vehicle NVH: Windnoise, Roadnoise and Powertrain. Windnoise is the sound generated primarily by air rushing over the front of the vehicle near the driver and passenger's head. Roadnoise is input from the tires' rolling contact with the road surface. This can be tactile and audible. Finally, Powertrain NVH is tactile and audible NVH generated by engine input.

- **Performance** in the most general of terms is the capability or capacity associated with the manner in which something functions. Specific vehicle level examples would include maximum speed of operation, handling capability, cargo hauling, pushing or pulling.

- **Efficiency** is typically measured in terms of other attributes such as fuel consumption: “The ratio of the work done or energy developed by a machine, engine, etc., to the energy supplied to it, usually expressed as a percentage” Energy usage by an appliance or electronic device or fuel consumption by an automobile are easily recognized measures of this attribute. Efficiency can also be used to describe the simplicity of a design or process: “Accomplishment of or ability to accomplish a job with a minimum expenditure of time and effort: The assembly line increased industry's efficiency..”

- **Ergonomics** is the measure of the relative ease of use of a device. The ease with which an operator can locate, touch, read and understand controls for a device are key to a successful design. Examples include door handle location, instrument panel layout and overall control placement. With the increasing electronic complexity of modern vehicle designs, it is key to have a logical arrangement of controls to avoid operator confusion and dissatisfaction.

- **Size / Usage / Comfort** is a description of how well a product accommodates different sized users. In automotive terms it is better described as Occupant Package, or Accommodation and Usage and is measured by the size, spaciousness and cargo carrying capacity of a vehicle.

- **Safety** is the real or perceived level of comfort an operator has that he / she is safe from danger, risk or injury. Most pertinent to vehicle design are government and third party crash safety standards for front and side impacts and rollovers.

- **Price** is the end cost to acquire a product by the end customer. In automotive terms it is the purchase price of the vehicle. It is important to recognize that this is not a measure of the manufacturing cost of a product as, although this may

have an effect on end price, it is only a single constituent of it and may vary producer to producer based on manufacturing efficiencies. The customer doesn't care how much it cost to produce a vehicle, only how it compares in purchase price to other competitors.

- **Recyclability** has emerged in recent times as a key attribute measure of a product appeals to the visceral motivation of the user. Rather than being directly or objectively measured, this attribute leaves the user with a feeling of goodwill towards the environment.

PERCEPTION OF ATTRIBUTES

Attributes can be directly or indirectly perceived. Directly perceived attributes can be either geometric (styling, spaciousness) or performance based (handling, 0-60, fuel economy). Customers describe vehicles in terms of directly perceived attributes as perceived by one or more physical senses as shown in [Table 4](#).

<table 4 here>

Other characteristics of a vehicle's behavior are not directly customer-perceived but may be considered attributes in either engineering/design communities or among enthusiasts. These “attributes” are typically a constituent of a higher level attribute that a customer will notice. Examples include aerodynamics (which effects fuel economy, windnoise and top speed capability) and weight (which also manifests itself in fuel economy as well as performance and handling capability). Average customers do not describe vehicles in terms of indirectly perceived attributes but they will sometimes encounter them in enthusiast magazines.

In summary, attributes within vehicle design are customer perceived characteristics. Generally speaking, in the absence of error states, how well a product performs against the above comprises its attribute performance.

REQUIREMENT CLASSIFICATION

Having explored the breakdown of requirements into manageable elements, we can now turn to types of requirements. Remember that requirements are measureable characteristics with limits or optimal values. Defining different requirement types allows engineers to:

- Separate “Must Do” and “Should Do”
- Ensure corporate policy is carried out
- Ensure focus on competition
- Protect brand
- Maximize customer satisfaction
- Document severity of non-compliance