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## The Lean Value Principle in Military Aerospace Product Development

Extracted from:

"The Application of Lean Principles to the Military Aerospace  
Product Development Process"

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## Foreword

Recent research by James P. Womack and Daniel T. Jones suggests that application of five lean principles to the processes across the entire enterprise will lead to achieving a “lean” state. This lean state results from the elimination of waste from operations such that products can be developed with a minimum of overall expense in terms of human effort, material and time. The specific principles are: precisely specify value by specific product, identify the value stream, make value flow, let the customer pull value, and pursue perfection.<sup>1</sup> Nevertheless, the bulk of the discussion and application examples in this and other recent research have largely been focused on the manufacturing portion of the value stream. There are many examples in industry of where these principles have successfully transformed manufacturing organizations. But there are striking differences between the processes used in manufacturing settings and the product development setting, and there are striking differences in the ‘product’ which these processes produce. The general problem to be studied is whether value stream mapping and lean principles, which have been successful in facilitating the lean transition in manufacturing, are effective tools in identifying waste and identifying an improved product development process future state.

This document takes a critical look at the first lean principle, Value. The meaning of value is investigated first in a general context, in the context of Lean Thinking, and finally in the context of other product development and business literature. This investigation found the value principle to be pertinent in the product development context and a specific definition of value was developed which facilitates an understanding of customer value in the product development arena, and assists in creating a customer focus in the lean transition process. Although Lean Thinking is customer value focused, the existence of other value perspectives is investigated. The linkage between these value perspectives is also discussed and the need to understand these linkages during the lean transition is established. Finally, specific high level attributes of customer value in the product development setting are established.

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<sup>1</sup> James P. Womack and Daniel T. Jones, *Lean Thinking: Banish Waste and Create Wealth in Your Corporation* (New York: Simon & Shuster, 1996), 10.

## The Value Principle and Its Perspectives

Value is the first lean principle offered in Lean Thinking. Womack and Jones emphasize the need to express value in terms of a specific product that meets customer needs at a specific price at a specific time.<sup>2</sup> In order to assist in defining what is meant by value specifically in the product development process, it is appropriate to review definitions of value in modern literature and in contexts other than the product development. What better place to start than the Oxford English Dictionary for an understanding of what is meant by the term ‘value’ in value stream. The first definition for value in this reference is as follows:

- 1a. That amount of some commodity, medium of exchange, etc., which is considered to be an equivalent for something else; a fair or adequate equivalent or return.<sup>3</sup>
- 1b. A standard of estimation or exchange; an amount or sum reckoned in terms of this; a thing regarded as worth having.<sup>4</sup>

Based on definition 1a, it is evident that in the context of this work that value implies equivalence between the cost of a product to the customer and the product itself. Note that this consideration of equivalence is in the eyes of the customer and not of the producer. Additional insight is gained by the third statement in 1b; “a thing regarded as worth having”. The summation of value added along the value stream must be great enough that the customer deems the product as worth having. And in fact the Oxford English Dictionary includes the phrase “value added” in its definition of value and defines it as:

the amount by which the value of an article is increased at each stage of its production by the firm or firms producing it, exclusive of the cost of materials and bought-in parts and services<sup>5</sup>

This is the value we are talking about mapping in the product development process, although we may choose not to exclude anything. There is one more aspect of the definition, which adds to this discussion, and that is a reference to the product usefulness or function. Again from the Oxford English Dictionary:

- 6a. The relative status of a thing, or the estimate in which it is held, according to its real or supposed worth, usefulness, or importance.
- 6f. The quality of a thing considered in respect of its power and validity for a specified purpose or effect.<sup>6</sup>

These definitions tie the previous customer’s perception of worth directly to the product usefulness for a purpose and importance. And interestingly, the definition also ties in the product’s quality to its value. Prior to considering the specific product development

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<sup>2</sup> Womack and Jones, *Lean Thinking*, 16.

<sup>3</sup> *Oxford English Dictionary*, 2<sup>nd</sup> Edition (1989), s.v. “value”.

<sup>4</sup> *Ibid.*, s.v. “value for money”.

<sup>5</sup> *Ibid.*, s.v. “value added”.

<sup>6</sup> *Oxford English Dictionary*, s.v. “of..value”.

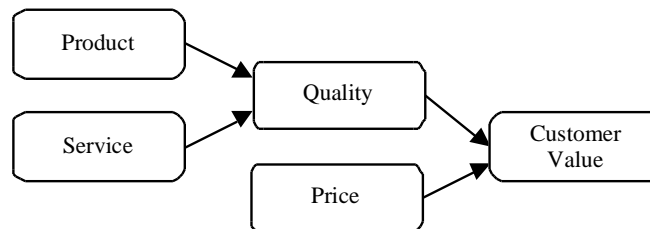
context, the following summation is proposed for the meaning of 'value' for use in this study:

**Value is a measurement of the worth of a specific product or service by a customer, and is a function of (1) the product's usefulness in satisfying a customer need, (2) the relative importance of the need being satisfied, and (3) the exchange cost to the customer.**

Note that this is an initial definition which is revised later as other contexts are considered.

## Customer Value

We now turn to other possibly more pertinent sources for our definition of value in the context of product development. Overall, there seems to be reasonable agreement in the definition of value in recent publications relating to value in the business environment. In *Managing Customer Value*, Bradley T. Gale suggests a relationship for value as shown in Figure 1.



**Figure 1. Customer Value Relationship**

Gale defines Customer Value as market perceived quality adjusted for the relative price of the product or service, where market perceived value is the customers opinion of the product or service relative to those of the competition.<sup>7</sup> In this definition, Quality includes all non-price attributes associated with both the product and/or service. An aspect of this definition missing from the previous discussion is that value is defined relative to the competition.

This market perception approach to defining value is different than the Lean Thinking perspective. Womack's approach demands putting benchmarking and measurement relative to the competition aside. Lean Thinking suggests an absolute approach where value is be measured against an ideal, a condition without muda. In other words, value should be measured relative to perfection. The counter argument is that the customer is sensitive to his needs in the context of the entire market. The customer will naturally compare products to each other to establish which one best satisfies his utility function for value. If the

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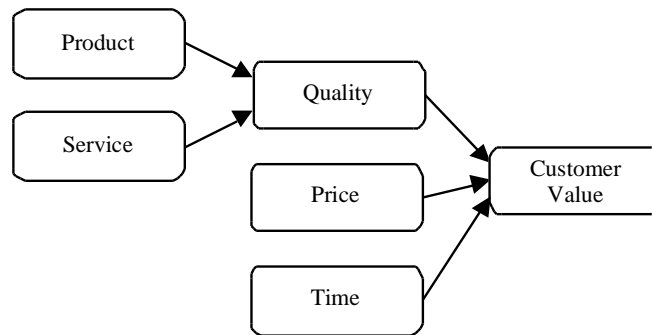
<sup>7</sup> Bradley T. Gale, *Managing Customer Value: Creating Quality and Service That Customers Can See* (New York: The Free Press, 1994), XX.

customer is doing this comparison, then it behooves the business enterprise to understand the competition.

The measurement against perfection seems appropriate when one is focused on the “Price” portion of the value equation. A company should strive to eliminate all waste and thus achieve the ‘ideal’ cost of producing a given product or service. But this ‘ideal’ is based on a given set of non-price product or service attributes, the “Quality” portion of the value equation. There is no ‘ideal’ set of non-price product attributes, rather these attributes are variables from company to company based on target market segments and product positioning strategy. Differing targeted market segments will have differing desired non-price product attributes. So it seems that the two major elements of value could benefit from different measurement techniques, an absolute approach for “Price” attributes and a relative approach (to the competition) for non-price attributes.

This apparent difference in approaches to value measurement can be partially explained by the focus on a specific product in the Lean Thinking approach. The market analysis is complete and many product quality attributes have been established by the time our consideration is down to a specific product. Value maximization in this case is then focused primarily on the non-quality value attributes.

In *Value, It’s Measurement, Design and Management*, the authors, M. Larry Shillito and David J. DeMarle, make a strong case that value is a function of time.<sup>8</sup> This is consistent with the Lean Thinking inclusion of “at a specific time” in the definition. The timing of when a product reaches market has a strong influence over the perceived value of the product. Based on this assessment, the above model should be modified to include time as a primary factor in the makeup of value as shown in Figure 2.



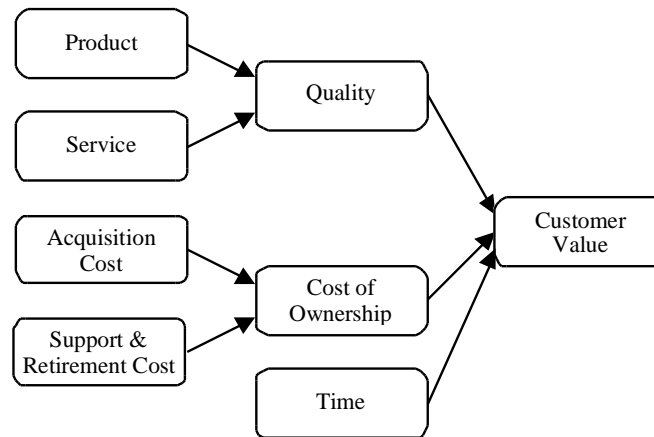
**Figure 2. Customer Value Relationship With Time Attribute**

Additionally, to add clarity to what is meant by price, this attribute should be redefined to be cost of ownership. In this manner, it is put into the customer’s perspective and both the acquisition cost and the other factors involved in life cycle costs to the customer can be

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<sup>8</sup> M. Larry Shillito and David J. DeMarle, *Value: Its Measurement, Design, and Management* (New York: John Wiley & Sons, Inc., 1992), 11-14.

accounted for. The Support and Retirement costs need to be considered here in addition to the acquisition cost due to the fact that they are significantly driven by decisions made in the product development process (Figure 3).



**Figure 3. Customer Value Relationship With Expanded Cost Attribute**

This model appears consistent with the criteria outlined in Lean Thinking for expressing value, that is in terms of a specific product, price and time.

Incorporation of the above additional perspectives in the definition of value results in the following:

**Value is a measurement of the worth of a specific product or service by a customer, and is a function of (1) the product's usefulness in satisfying a customer need, (2) the relative importance of the need being satisfied, (3) the availability of the product relative to when it is needed and (4) the cost of ownership to the customer.**

Shillito and DeMarle also take a more quantitative approach to describing the nature of value from which we can gain additional insight into the relationship between the attributes, which comprise value. Value is defined as being directly proportional to the product of the need for an object (or service) and the ability of this object to satisfy this need, and it is inversely proportional to the cost of the product or service.<sup>9</sup> Note this matches nicely with the word definition derived from the Oxford English Dictionary.

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<sup>9</sup> M. Larry Shillito and David J. DeMarle, *Value: Its Measurement, Design, and Management*, 9.

In mathematical terms:

$$Value = \frac{N \times A}{C}$$

Where:  $N$  = the need for the product or service  
 $A$  = the ability of the product or service to satisfy the customer need  
 $C$  = the cost of the product or service

The above formulation is very similar to that used in traditional Value Engineering where value or a value index is defined as the ratio of essential function over cost. Value analysis uses this ratio to assist in identifying lower cost approaches to provide a given function. This formulation is also quantitative in nature and lends itself to comparative assessments along the value stream.

But the above formulation does not capture the time sensitivity of value. Keeping it general at this point, we can generate what amounts to essentially a customer utility function for value as follows:

$$Value = \frac{N \times A \times f(t)}{C}$$

Where  $f(t)$  provides the dependency for the timing of the product or service. Since this time function is likely to depend on many factors and may vary from one case to another, we will not further define it at this juncture.

The above value discussion is generic in nature and still at least one level of abstraction too high for application use in value stream mapping and process improvement. We started with the generic term value, moved on to the term value as it pertains to the product development process, but up to this point we have not dealt with a specific product nor involved a specific customer in this process. A key aspect of lean thinking is to focus on value as defined by the customer for a specific product. The above variables need to be put into specific customer and product terms during the process of mapping. Any lean effort in the product development realm must start with specific understanding of the customer's perspective on value. This lower level of abstraction and detailed application is discussed in a case study in the thesis of Slack.<sup>10</sup>

This section provides a basis for an understanding of customer value. But this understanding is not complete without considering the existence of other value streams and the potential interactions or linkages between them. These interactions and linkages are discussed in the following section.

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<sup>10</sup> "The Application of Lean Principles to the Military Aerospace Product Development Process", Robert A. Slack, Master of Science in Engineering and Management Thesis, Massachusetts Institute of Technology, December 1998.

## Other Value Perspectives

Up to this point, the definition of value has been from the customer perspective. Womack makes a point that ultimately this is the only value that matters. But the fact is, there are other value perspectives, which could influence the success of implementing value stream mapping and lean thinking in the product development organization. Two other perspectives are that of the shareholders and that of the employees. Why consider these other perspectives? In *The Value Enterprise*, John Donovan, Richard Tully and Brent Wortman propose that management processes should be developed to ensure simultaneous optimization of investor, customer and employee value.<sup>11</sup>

One question which this raises is whether it is suitable to focus only on improvement of Customer Value, with Shareholder Value and Employee Value being a fallout of this process, or whether Customer and overall system value maximization would benefit from a broader focus on all three perspectives. Even if you accept that focusing on a single value dimension is sufficient, there is not consensus in business literature as to where to apply this focus. Although Lean Thinking is clearly customer value focused, there are other researchers, like Peter G. W. Keen author of *The Process Edge*, who believe that shareholder value is the driver of our age.<sup>12</sup>

The more global view would suggest that beyond the customer, the employee and the shareholder dimensions, that there are other stakeholders; suppliers, the community, and the environment for example that also should be considered in the value creation process. John Donovan et al, suggest that the most successful companies create value for all stakeholders, creating win-win situations where enough value is created for each one to prosper. Unless the primary constituencies receive sufficient value, the enterprise will not prosper, customers will go to competitors, investors will invest elsewhere, and employees will seek employment elsewhere.<sup>13</sup>

Robert S. Kaplan and David P. Norton offer yet another perspective which supports the need to consider multiple value perspectives. In *The Balanced Scorecard*, these authors discuss observations which they have made working with many companies wherein there is recognition that a single measure cannot provide adequate insight into critical business areas. Similar to the concerns which Womack raises relative to the potential for localized process improvement leading to sub-optimization of the entire value stream, *The Balanced Scorecard* warns against single dimension measures due to potential sub-optimization of performance.<sup>14</sup> The authors propose four perspectives for performance measures or goals to provide business strategic direction, two of which align directly with

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<sup>11</sup> John Donovan, Richard Tully, and Brent Wortman, *The Value Enterprise: Strategies for Building a Value-Based Organization*, with a forward by Barry Hedley (Toronto: McGraw-Hill Ryerson Limited, 1998), xi.

<sup>12</sup> Peter G. W. Keen, *The Process Edge: Creating Value Where It Counts* (Boston: Harvard Business School Press, 1997), xiv.

<sup>13</sup> Donovan, Tully, and Wortman, *The Value Enterprise*, 18.

<sup>14</sup> Robert S. Kaplan and David P. Norton, "The Balanced Scorecard – Measures That Drive Performance," *Harvard Business Review* (January-February 1992): 71-73.



the value perspectives proposed herein:

- financial perspective equates to shareholder value
- customer perspective equates to customer value
- internal perspective
- learning perspective

To evaluate whether the previously defined value linkage model needs modification in light of these additional perspectives, the internal and learning perspectives need to be further defined. Kaplan and Morgan offer the following relative to the internal perspective:

Customer-based measures are important [direct measures of customer value], but they must be translated into measures of what the company must do internally to meet its customers' expectations....Managers need to focus on those critical internal operations that enable them to satisfy customer needs....Managers need to decompose overall cycle time, quality, product and cost measures to local levels.<sup>15</sup>

This suggests that the internal perspective dictates measurement of internal process performance along the customer value stream within a business, and that these measures are in direct support of maximizing customer value. Based on these facts, the internal perspective is not an additional value perspective. It is another interpretation of the need to focus on the customer value stream within the business organization and hence is consistent with the Lean Thinking approach.

Kaplan and Morgan offer the following relative to the learning perspective:

A company's ability to innovate, improve, and learn ties directly to the company's value. That is, only through the ability to launch new products, create more value for customers, and improve operating efficiencies continually can a company penetrate new markets and increase revenues and margins – in short, grow and thereby increase shareholder value.<sup>16</sup>

This again suggests that the learning perspective is not a unique value perspective, rather it is a perspective for operating improvement measurement and goals, which support increased customer and shareholder value. The Balanced Scorecard clearly supports multiple value perspectives, customer and shareholder, although it makes no mention of employee value. And it is complimentary to Lean Thinking:

- Both share a customer value focus.
- Both recognize the need to focus on the internal activities which support the generation of customer value (value stream in lean terms).
- Application of lean principles is an improvement strategy which is encouraged by the learning goals in The Balance Scorecard.
- Implementation of value stream mapping creates an opportunity to identify the key operating parameters required to generate a balanced scorecard.

The bulk of evidence in recent research supports the multiple perspectives of value. A decomposition of the customer value perspective into value attributes has been proposed to

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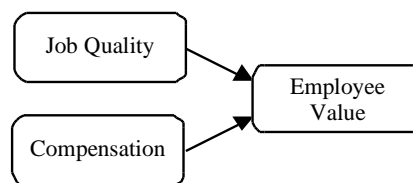
<sup>15</sup> Ibid., 74-75.

<sup>16</sup> Kaplan and Norton, *The Balanced Scorecard*, 75.

facilitate an understanding of this perspective and to facilitate customer value creating improvement efforts. To create value for the other primary stakeholders, it is necessary to gain an understanding of the unique value attributes of each value perspective, specifically, employee value and shareholder value.

## Employee Value

The employee value perspective can be decomposed similar to the method used for customer value decomposition. Donovan, Tully and Wortman offer a similar approach to defining employee value as was used to define customer value. The value an employee takes away from his or her job is a function of both the compensation the employee receives from the company as well as job quality.<sup>17</sup> In this case, job quality consists of all non-compensation based attributes associated with working at the firm. This can be represented as shown in Figure 4.



**Figure 4. Employee Value Relationship**

Since job quality and compensation are from the employee's perspective, these are inherently measured relative to what is available elsewhere in the job market. Compensation includes base salary and other compensation based attributes like health care benefits and retirement benefits. Job quality attributes include work/life balance issues, training and skill development, performance management, and growth opportunities. Different employees will have different utility functions associated with job quality, similar to the customer relationship with product quality. By creating value for employees, firms can develop an advantage based on their people and their skills, ultimately leading to competitive advantage in the marketplace.

## Shareholder Value

The value of the product development process to the shareholders is the potential for future sales and profits of the realized product. The greater the margin achieved for a given product, the greater the value of that particular program to the company. Contrary to customer and employee value, the shareholder perspective of value is purely an economic concept. The concept of Economic Value Added (EVA) states that a company only creates value for its shareholders when its operating income exceeds the cost of

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<sup>17</sup> Donovan, Tully, and Wortman, *The Value Enterprise*, 71-72.

capital employed. Robert C. Higgins in *Analysis for Financial Management* defines EVA as follows:<sup>18</sup>

$$EVA = EBIT * (1 - TaxRate) - Kw * C$$

Where:  $EBIT * (1 - TaxRate)$  = the firms after-tax operating income  
 $Kw$  = its weighted-average cost of capital  
 $C$  = the capital employed by the firm (creditors and owners investment)

EVA can be used for investment analysis, including investment opportunities in a firm's processes. These opportunities are evaluated by calculating the present value of the investment's annual EVA. Thus we can evaluate the shareholder value created for a given investment. This is accomplished by calculating the opportunity cost of capital employed, which is equal to the cost of capital times the book value of the investment. Subtracting this from the expected EBIT minus tax, results in annual EVA, which is discounted to establish present value.

### **Linkage of Value Perspectives**

A suggested generic model for linking the three primary value streams, customer, employee and shareholder, is shown in the Figure 5. In this figure the primary attributes for each value stream are shown; product quality, price and schedule for customer value, job quality and compensation for employee value, and economic value added for shareholder value. Additionally, links between these attributes are shown which provide some insight into the interactions between the value streams.

The link between customer value and shareholder value can be described as follows; increasing customer value relative to the competition will lead to additional demand for the company's product which increases revenue. The increased revenue minus the fixed and variable costs associated with producing the product results in increased earnings before interest and taxes, and finally after interest and taxes and the cost of capital are taking into consideration, the economic value added (EVA) results in an impact on shareholder value. Increased shareholder value stimulates additional investment, both in terms of the company's product offerings as well as in the workforce. Hence the linkage between shareholder value and customer and employee value. The resulting improvements in product and job quality then have a direct bearing on customer and employee value. An additional linkage worthy of discussion is that associated with employee compensation. Increased compensation improves employee value, while increasing costs which has a potentially negative impact on customer and shareholder value. In this case there are several influencing factors, the increased cost associated with higher compensation, and potential improved productivity and product quality associated with the higher employee value. The resulting impact on customer value and shareholder value will depend upon the strength of these interactions.

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<sup>18</sup> Robert C. Higgins, *Analysis For Financial Management*, 5th ed. (Boston: Irwin/McGraw Hill, 1998), 299.

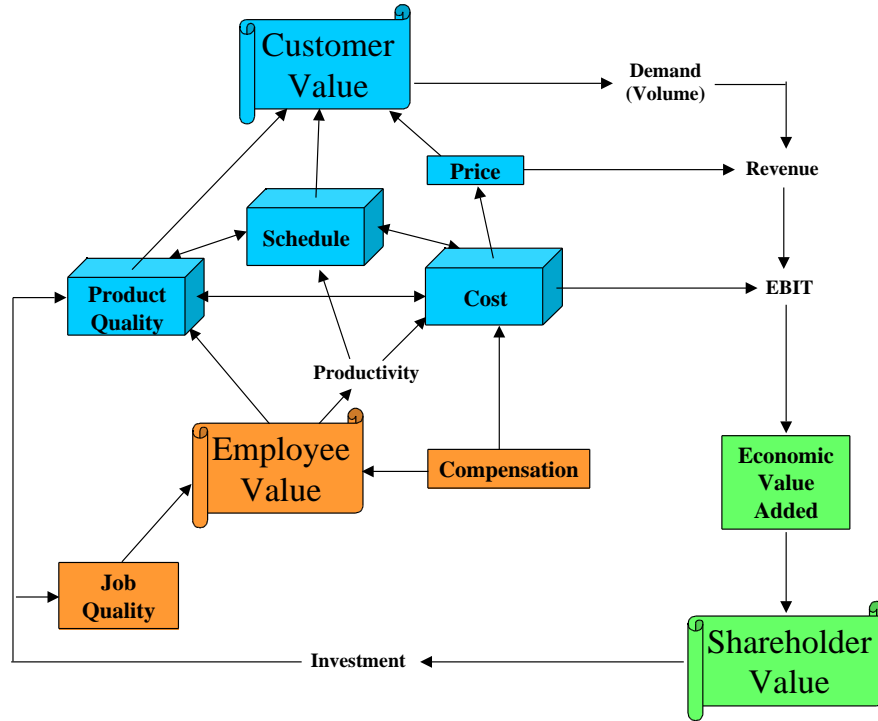


Figure 5. Model For Linkage of Multiple Value Perspectives

This model is not meant to be a rigorous model of the overall enterprise. Rather it is meant as an aide to visualize the relationships between the differing value streams and to help bound the nature of this thesis. It is evident that changes in one value stream have impacts on others, and these impacts need to be understood (at least the direction of the impact) to improve overall enterprise value. As we identify lean improvements in the product development process to maximize customer value, a business case analysis is required to verify that the investment required to implement those improvements will provide a positive return for the enterprise enhancing shareholder value. Similarly, an understanding of the impact of these changes on employee value is necessary to ensure the long term viability of the improvements. If employee value is negatively impacted by a process change, it is less likely that the new process will be embraced and followed by the employees and that the anticipated benefits in customer value will be realized. This is particularly true in “white collar” processes like product development where process visibility is not as clear as it is in a manufacturing setting. In the manufacturing environment it is quite evident when workstations are moved and processes are redefined that the work force is working to the new process. In the office environment this visibility is not as clear and employees may revert back to the old ways of doing business if the lean effort does not take into account employee values.

In summary, it is acceptable to work within an uni-dimensional model focusing on customer value as long as the above analysis of employee and shareholder value is accomplished

prior to implementation of any change. There is good reason to simplify our model to the customer value dimension. A straightforward, simple approach to customer value stream modeling will facilitate the lean effort being enthusiastically embraced by the lean transition team.

## Customer Value Attributes in Product Development

This work is focused on the product development process, the customer value stream and its primary attributes of product quality, schedule and cost (Figure 6). Note that these attributes are often in tension during the product development process, and the resolution of this tension has a direct bearing on customer value.

Revisiting the equation for value,

$$CustomerValue = \frac{N \times A \times f(t)}{C}$$

- Where:
- $N$  = the importance of the need for the product or service. The value of  $N$  is fully determined by the customer.
  - $A$  = the ability of the product or service to satisfy the customer need. The value of  $A$  is determined by how well the product development process is executed.
  - $f(t)$  = the availability of the product or service to the customer, relative to the customer need date.
  - $C$  = the cost of ownership, is a function of product and service attributes as well as the efficiency of the product development process.

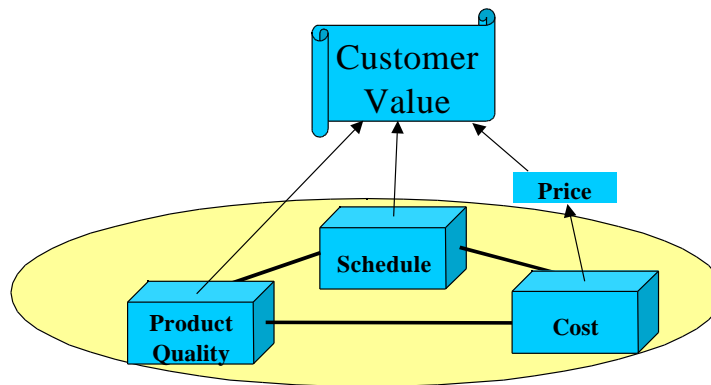


Figure 6. Primary Attributes of Customer Value In Product Development

Note that the quantity  $N$  represents the importance for a given product. In the context of development of complex systems, a given product may have a multitude of needs or

requirements with specific individual importance. The above equation therefore could be used to evaluate value for a given requirement or function, or it could be used to evaluate the aggregate value of the product. The generalized aggregate value equation takes on the form:

$$CustomerValue = \frac{\sum (N \times A) \times f(t)}{C}$$

Note that  $A$ , the ability of the product to satisfy the customer need, can be viewed in terms of probability. Viewed in this sense, the term  $A$  would increase as the product progresses through the product development process until verification of the requirement has been accomplished at which point it would be a maximum (1). A product which has demonstrated by test the ability to meet a requirement has eliminated the risk associated with this requirement and is of greater value to the customer than a product which has an element of risk associated with meeting this same requirement. The ability of the product to satisfy a customer need can be related to risk by the following simple relationship:

$$A = 1 - R$$

Where:  $A$  = the probability of a specific product meeting a specific customer requirement  
 $R$  = risk, the probability of a specific product not meeting a specific customer requirement.

With the above, we can establish a relationship between our definition of value and risk in the product development process.

$$CustomerValue = \frac{\sum [N \times (1 - R)] \times f(t)}{C}$$

The denominator of this equation,  $C$ , cost of ownership, is equivalent to the total life cycle cost of the product in the aerospace product development context. This life cycle cost includes:

- development program costs
- product acquisition costs
- support, operations and retirement costs

This implies that to maximize customer value in the product development domain we must consider all of these costs during development decision-making processes. Although only development program costs are actually expended during the product development process, the costs associated with acquisition, and support, operations and retirement, which may comprise on the order of 90% of the life cycle cost, are committed during the product development process. To maximize value, all of these costs need to be carefully considered during development prior to being locked-in. Understanding the customer's utility function for cost is also required. The customer's total budget picture and budget available versus

time may dictate how these costs get traded during the development program decision-making process.

Development program costs need to be controlled within budget limits using appropriate cost management techniques. This is particularly important from a customer's perspective on programs which are cost-plus type reimbursable contracts. Product costs are largely established by the chosen design of the product or system. Value maximization dictates that cost estimating models or tools be used during the design/development process to enable an understanding of impacts on product cost and to ensure that product cost targets are accomplished as the product is transitioned to production. This same discussion applies to support and operations costs. These costs should not be relegated to occasional consideration during design trade studies. Cost estimating models and tools should also be employed for support and operations costs, like they are for product costs, to ensure that product life cycle costs are understood and accomplished.

This total life cycle cost focus is appropriate for both the military and commercial aerospace industry sectors alike. New commercial contracting approaches for jet engine power may actually increase the need for this broad cost focus. Options to buy "power by the hour" exist, where airlines essentially lease engines by the flight hour, while the engine contractor owns and maintains the engines. This ownership and responsibility for support costs will heighten the contractor interest in understanding and controlling these costs when they are committed during the development phase.

The attributes of customer value can be expanded yet further when addressing the *A* term, the probability of a specific product meeting a specific customer requirement, from the numerator in the above equation. This term corresponds to the quality attribute which has been introduced as pertaining to all non-price attributes associated with the product. This attribute can be decomposed into two parts:

- functional and performance properties – what functions does the product provide and what performance is offered for each of these functions
- degree of excellence – the degree of excellence in providing intended function and performance (or its inverse; this could also be discussed in terms of defects – shortfalls in providing intended function and performance)

These sub-attributes apply to both products and services and again are based on customer perceptions. Although this decomposition may be obvious, it is an important distinction given the differing actions required by a firm to provide these two different attributes.

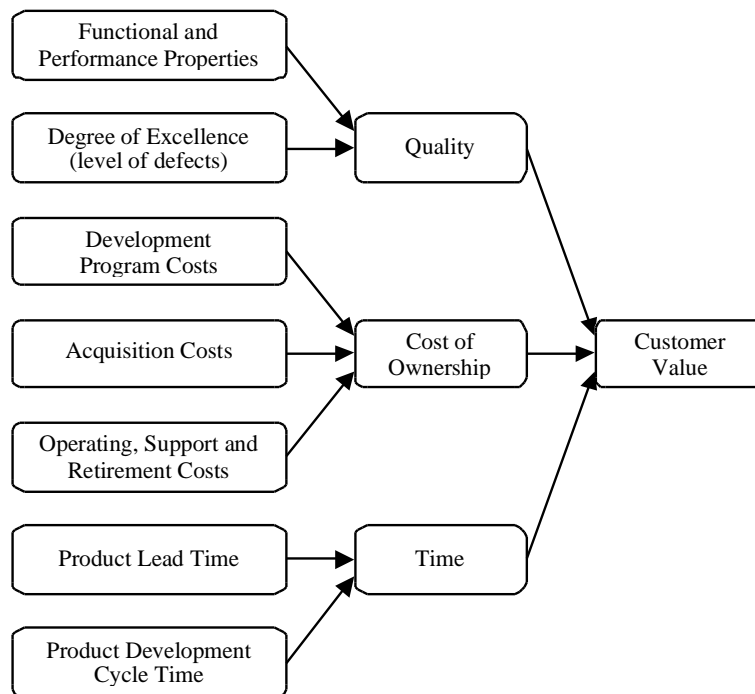
Similarly, the time or schedule function in the numerator of the above equation,  $f(t)$ , can be decomposed into two elements or attributes in the product development context:

- Product lead time – amount of time from order placement to availability or delivery to the customer.
- Product Development Cycle Time – amount of time from identification of the market need for the product to initial availability or delivery to the customer.

The considerations of this product development discussion are included in the customer value model as shown in Figure 7.

## Summary

In this report the definition of customer value and the attributes of this value are investigated in depth. Value is defined as a measurement of the worth of a specific product or service by a customer, and is a function of the product's usefulness in satisfying a customer need, the relative importance of the need being satisfied, the availability of the product relative to when it is needed and the cost of ownership to the customer. The existence of other value perspectives, specifically employee and shareholder value, along with unique attributes and linkages with customer value, is also proposed. These linkages suggest that all three primary value perspectives need to be considered in the pursuit of the lean product development organization. Finally, specific attributes of customer value in the product development setting are discussed. These attributes involve the classic tension between performance, cost and schedule, and a link between value and risk is proposed.



**Figure 7. Expanded Product Development Customer Value Model**



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