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## **CLOSING THE LOOP: PRODUCT SUPPORT OPERATIONS WITHIN THE DEMING SYSTEMS MODEL**

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### **Abstract**

*This paper introduces the concept of Product Support Operations (PSO) as an extension of traditional processes such as manufacturing and supply chains using the relational Deming Systems Model. The Deming Model will be expanded to include key system interactions occurring after the customer has purchased the product or service. This modified Deming Systems Model will be used to explain the concept of a Product Support Operations (PSO) function as a holistic means to improve customer service and product performance within the context of how the customer uses the product. This paper is aimed at professionals seeking to better understand internal organizational interactions in relation to customer needs and requirements. Academics interested in understanding design implications of a product support model may also find value with the material in this paper.*

### **Keywords**

Product Support, After-Sales Support, Integrated Logistics Support, Deming Systems Model

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## **1. Introduction**

The concept of product support has evolved significantly as product designs become more complex and customer budgets become more constrained (U.S. Department of Defense, 2016). The

role of logistics has moved from moving products to wherever it is needed to a more holistic approach which includes how the product is used (Sols, 2017). The proliferation of high-technology solutions in many industries (i.e. automotive, defense) result in more complex and difficult to operate products that create an environment in which customer technical capability may be inadequate. Increased product capability is not without its costs: products in high technology industries frequently take longer to design and are more costly for the customer to operate and maintain (U.S. Department of Defense, 2016). Increasing global competition exposes manufacturing organizations to diverse customer bases with diverse needs, requirements and tastes which can be difficult to apply to a product design (Ghodrati & Ahmadi, 2013). The emergence of these increased competitive pressures create an environment in which organizations are forced to provide increased product variety, features, and quality products and services at a faster pace (Bigorra & Isaksson, 2017).

These pressures have created a paradox faced by service and manufacturing operations managers between absorbing variety (caused by complex customer needs) and controlling costs (caused by design and manufacturing costs associated with applying customer needs into a product design). An operations management system offering products with high variety (i.e. multiple functions and capabilities of a product) subsequently increases manufacturing or service product offering complexity and cost (Barreto & Martins, 2017). The design of a service or manufacturing operation should therefore absorb sufficient product variety while also reducing variation and making products that appeal to multiple types of customers (Bicheno, 2012).

Product support (also sometimes called after-sales support or customer support) is defined as any form of assistance manufacturers or suppliers offer to users or customers to assist them in gaining maximum value from the product (Ghodrati & Ahmadi, 2013). The concept of a product support framework is important to organizations in that it can improve the reliability of a product design (Shukla, Kumar, Selvaraj, & Rao, 2014). Product support operations also benefit product design (and subsequently product benefits to the customer) by improving the capability of an organization to identify the source and type of variety (and ensuing variation) felt by the customer due to product design and pull resources to absorb or reduce variation within the existing design (Seddon, 2005). The concept of Design Interface (DI), a subset of product support, improves product design using a three-prong approach: improved subcomponent interface and design of within the context of a larger system, integrating supportability design parameters into overall system design, and applying supportability design factors to improve system utilization and maintenance (Dallosta & Simcik, 2013). These three

elements impact how a system design meets system availability, ownership cost, and logistical footprint (defined as the amount of physical space in hardware, test equipment, and spare parts required to support a particular design) using trade-offs reflecting customer priorities (i.e. a customer may favor availability over cost or vice versa) (Dallosa & Simcik, 2013). An overall product support strategy focuses on designing support capability into product design, product design based on performance goals, resource alignment to assist the customer in using the product, and providing support during the entire product life cycle at the lowest cost possible (Sols, 2017).

A product support strategy differs from traditional manufacturing or service operations strategy in that it involves both tangible and intangible assets. These tangible and intangible assets are aligned by service and manufacturing operations elements within the organization to improve how the customer uses the product (Barreto & Martins, 2017). The PSO provides support for a tangible product which requires the allocation of physical resources from the larger organization to facilitate the return of a product to either a like-new or serviceable state. However, much of the PSO function relies on the use of intangible assets (i.e. information) in the form of problem-solving processes. These problem-solving processes are essential to the function of the PSO in that it allows for problem identification and failure resolution as required by the customer. The PSO is also similar to service operations in that the customer is located at the front of the operations design (i.e. a hospital interviews a customer to determine the service offering he or she requires) with similar determinations of service types to offer the customer (Barreto & Martins, 2017). This initial customer focus is required within the PSO context to define product support scope and capabilities as it relates to organizational strategy and how it is reflected in customer requirements.

Product support strategies allow organizations to design variety absorption into its operations which subsequently allows the organization to better reduce variation through product design. Product support operations (PSO) are similar to service operations in that both have a high level of customer engagement (Barreto & Martins, 2017). This customer engagement provides the opportunity for other organization elements to better understand customer needs by observing how customers use the product and subsequent improve the product by aligning product characteristics towards those operational characteristics most important to the customer. This benefit is not without its risks; the PSO faces high variety caused by such things as failure demand (defined by Seddon (2005) as not doing something right the first time), capability variation (defined by Barreto & Martins (2017) and Bicheno (2012) as variation in the capabilities of the customer), and request variation (defined by

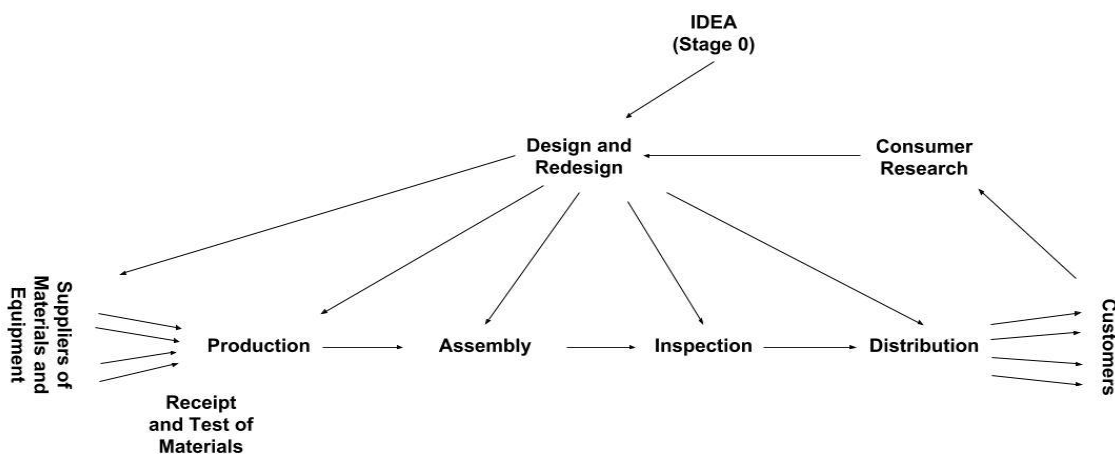
Bicheno (2012) as variation within a service arrival such as the myriad of potential demands the customer places upon the PSO). An effective PSO strategy must therefore also focus on absorbing variety created by the customer.

## 2. The Deming Systems Model

The Deming Systems Model (DSM) provides a means to reflect customer-oriented design elements within a product support framework using an overall organizational context. These design elements not only include product support but also those factors responsible for product designing and manufacturing. The inclusion of a product support role within manufacturing or service operations must therefore be designed to identify variation experienced and created by the customer, resolve effects of this variation, and provide feedback from variation resolution to internal organizational design functions for application into existing and future system designs (Shukla et al., 2014).

The Deming Systems Model (DSM), shown in figure 1, illustrates the main concepts behind viewing the organization as a system. The DSM begins at the Idea Generation stage (called Stage 0 on the diagram) where customer expectations, likes, and dislikes (defined as needs in this paper) are conceptualized. The next stage, Design and Redesign, initially converts understanding of customer needs into design specifications that are subsequently flowed to various roles and suppliers within the manufacturing process. These manufacturing processes are aligned based on particular product design requirements (i.e. additional testing and inspection processes may be added to the model).

Deming Simplified System Diagram



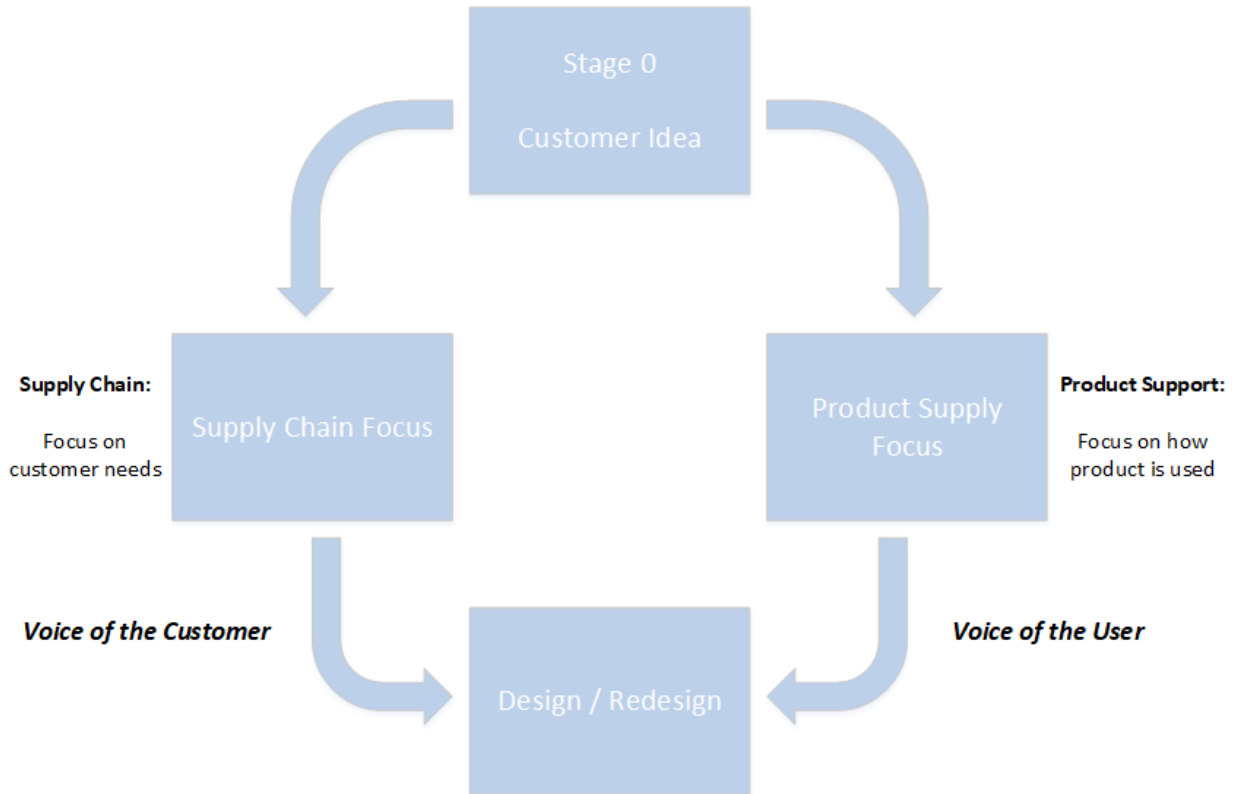
Modified from Deming, Out of the Crisis

Figure 1: The Deming Systems Model

Supplies and equipment (specified in requirements documents derived from the Design/Redesign stage) are delivered to the Production processes within the organization responsible for receiving and testing the incoming materials as specified in the design requirements documents). The tested materials are received by the manufacturing processes involved in creating and distributing the product to the customer (as before, the number of processes between the material suppliers and the customer can differ based on product design and manufacturing requirements). The customer receives and uses the product and provides feedback to the Consumer Research stage (either directly – through tools such as surveys – or indirectly through organization-directed market research). Feedback received by the Consumer Research stage is then provided to the Design and Redesign stage in an iterative loop.

Arguably the most important element in the DSM is the concept of stage 0 which drives the actions of all entities within the model. Stage 0 provides the system with what Deming called *constancy of purpose* (defined by Deming (2000a) as a focus on a common goal by all entities within the system) essential for performing as a system. Another important element within the DSM is the illustration of interdependencies between all entities within the system. These interdependencies highlight an important rule of systems in that a system's effectiveness relies on interactions between its parts rather than the actions of parts taken separately (Ackoff, 1999).

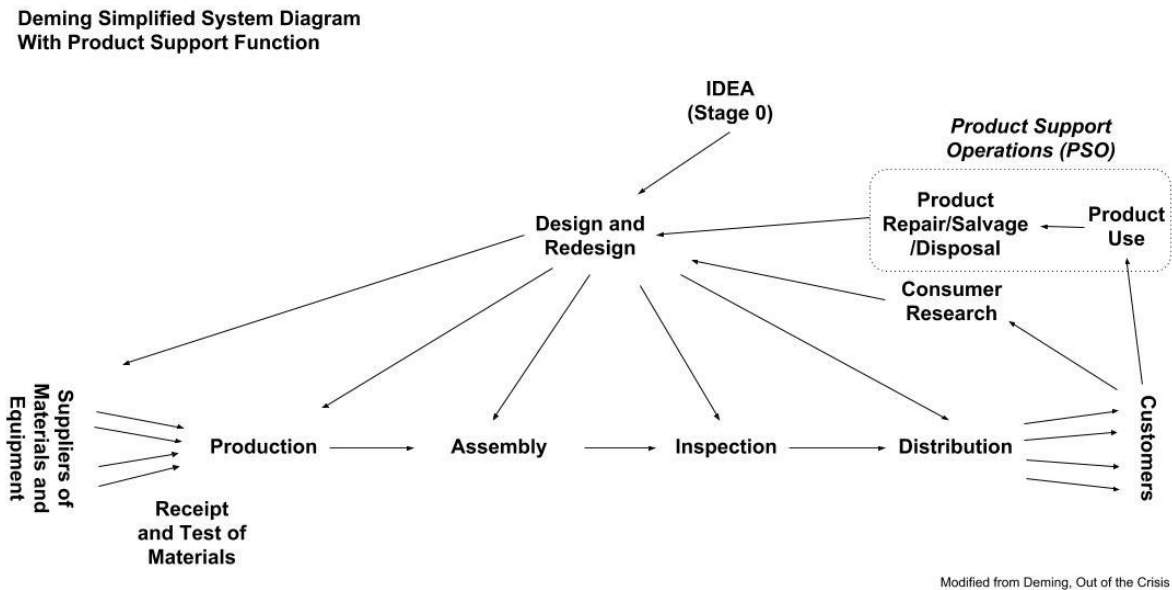
The product support concept of stage 0 differs from the traditional DSM concept by focusing on *how the product is used* and *how product design meets customer needs* rather than *how the product meets customer requirements*. This is an important distinction as it adds an additional layer of engineering focus within the Design/Redesign stage to accommodate both contexts. The traditional stage 0 concept aligns the efforts of entities within the system towards ensuring that *customer needs* are addressed. The expanded DSM (which includes the product support function) expands the goal of the system to also consider *user needs*, a concept which can be described using a House of Quality model to include the additional “voice” the PSO DSM provides.



**Figure 2:** *Supply Chain and Product Support Focus on Design/Redesign*

An important shortcoming of the DSM model is that it provides limited information on customer and organization interactions beyond the point of product receipt by the customer. The DSM highlights the customer and the steps involved in understanding these needs yet does not address key interactions between the customer and organization in relation to how the product is used. The PSO function (shown in figure 3 below) expands upon the original DSM by adding two important stages. The first stage, Product Use, provides a means for the organization to understanding how the customer uses the product and how it performs within the customer's specific context. This key concept is the basis for the Voice of the User (VoU) within a House of Quality model. The second step, Product Repair/Salvage/Disposal, represents customer decisions made in relation to a product failure or malfunction. The customer may choose to either repair the product (when deviations occur from expected or desired performance in relation to product use), salvage the product (when the product has fulfilled its expected lifecycle and the customer wishes to remove any serviceable or reusable components from the product), or dispose of the product (e.g. products requiring special procedures such as hazardous waste). PSO interactions with the customer during the Product Use stage can be either customer-initiated contact (e.g. to address product-related questions) or direct interactions with

organization personnel assigned to aid the customer in product use or repair (e.g. aircraft technicians assigned to a customer location).



**Figure 3:** *The Deming Systems Model including Product Support Operations Function*

In each scenario important product performance information is gathered and provided to the Design and Redesign function to make product-related improvements. This critical element of PSO provides the potential for value-added product spiral development in relation to customer needs. Note however that it is possible for how the product is used to differ from initially defined requirements previously identified in Step 0 or the Design and Redesign stage (e.g. military equipment in which specifications are set by individuals different than the end user). The organization can subsequently engage with the customer (or customers) to identify the best means to align product performance to customer needs in situations where initial Stage 0 differ from these lessons learned gathered by the PSO.

### 3. PSO System Model Benefits to Manufacturing Operations

The PSO system model is valuable to manufacturing operations such that it expands the role of each entity within the system to include how the customer uses and gains value from the product. For example, the Production function of the PSO System Model focuses not only on how its processes apply to product design but also how to manufacture parts which can extend the life of the product.

Conversely, production processes can be used during Assembly as a competitive advantage by implementing methodologies (i.e. principles of postponement) that can also make the product easier to assemble and disassemble (to provide the customer with increased repair capability).

Another significant contribution of a product support strategy to manufacturing operations is the inclusion of an overall customer strategy. Traditional manufacturing operations previously focused on customer wants and needs and translating these requirements into a design using an engineering function. A product support strategy can be used to not only identify these customer wants and needs but also to understand how these customer wants and needs as defined by the marketing function relates to how the product is actually used. This information can be used for future product improvements or offerings which better align with how the product is used. The PSO system model would benefit any product design which is complex, costly, and difficult to maintain and operate.

#### **4. Discussion**

This paper suggests two main areas in which the PSO concept can be expanded to add value to traditional manufacturing operations. The traditional Quality Function Deployment (QFD) concept can be expanded to include the “voice of the user” (VOU) within the House of Quality. Expanding the House of Quality to include end user behaviors allows manufacturing resources to understand how to directly benefit the customer by improving product operation and maintenance in relation to actual customer behaviors. This information can be invaluable since how a product is used can differ from how it is designed. Organizations can leverage such tools as Big Data and the Internet of Things can also be aligned with PSO elements to expand understanding of how product offerings are used through the gathering of real-time data more directly related to customer behaviors (Bigorra & Isaksson, 2017). The results of a House of Quality-type analysis can be expanded to include customer needs as manifest in how the product is used which can be applied to enhanced feedback models which reflect the “voice of the user” in future designs. QFD and House of Quality can also be effective in gathering and absorbing customer (end user) information and applying it towards solutions that benefit how the product is used and maintained (Bigorra & Isaksson, 2017). The product support function complements the traditional House of Quality model (which uses mostly qualitative information to describe desired and needed product attributes) as it is designed to understand customer usage and maintenance capability using quantitative data in addition to traditional qualitative methods.



The Product Support Operations (PSO) Deming Systems Model (DSM) also highlights an important distinction in how variation and variety is addressed in manufacturing and product support operations. The types and sources of variation and variety present in the manufacturing of a product differ from that present in product usage. A main difference between the two types of operations is in that variation is *reduced* during manufacturing through conformance to requirements whereas variation during product usage should be *absorbed* by product support elements (Seddon, 2005). This important distinction requires process designs that function with different variety and variation resolution strategies.

## **5. Conclusion**

The evolution of costly and technically complex products has created a scenario in which manufacturing operations must move away from simply providing a product to offering life-cycle support. The introduction of a product support strategy can provide a source of competitive advantage by improving product usability and increasing the life of a product at a lower cost (Sols, 2017). The PSO model provided in this paper moves the Deming System Model to a more holistic approach in which the customer role in manufacturing is expanded.

The ideas presented in this paper provides two paths to improving manufacturing operations. The Quality Function Deployment (QFD) model briefly mentioned can benefit from an improved House of Quality (HoQ) model which includes the *voice of the user* in addition to traditional voices present in the model. The HoQ model (similar to that started by Bigorra and Isakkson (2017)) can be modified to provide manufacturing operations with user-related information and apply it to existing quality processes and functions. The inclusion of a product support strategy as depicted in this model also requires manufacturing operations to address variation and variety differently due to differences in the sources and types of variation and variety. The model can be evolved from the basic elements provided in this initial design to a more robust model which includes more factors related to how product usage and maintenance relates to manufacturing.

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