

DESIGN AND EVALUATION PRODUCT SERVICE SYSTEM (PSS) FOR FURNITURE

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Abstract – Product Service Systems (PSS) is a business strategy that has potential benefits for companies in addressing the customer needs through the integration of products and services. In the current fierce market competition, this strategy is recommended to bring innovative solutions. Furniture is in high demand in the urban community. Therefore furniture companies compete tightly to develop products and services to meet customer's needs. This research will investigate the framework of PSS development for a furniture company by utilizing Multi-layer Quality Function Deployment methodology and Fuzzy-AHP. The development of PSS business model for the furniture company will also be presented in a form of PSS Blueprint. Furthermore, the evaluation of PSS design is also performed based on the perspective of customers and provider.

Keywords – Fuzzy-AHP, Multi-layer QFD, PSS development, PSS Blueprint, PSS evaluation

I. INTRODUCTION

The continuous development for sustainability currently becomes an issue for international interest and responsibility for many parties. Sustainable development is a development that meets the current needs without compromising the ability of future generations to meet their own needs. The study of sustainable development has attracted the attention of many parties. Until now, research of sustainability development in the industrial world is still often discussing about emission reduction. On the other hand, sustainable development can be done through resources efficiency, technological development orientation, and consumption pattern alteration to a better way.

The business development runs quite dynamic and it affects the competition between manufacturing industries. In competing through a rapid transition, the orientation of the products supply alone may not be able to maintain the company's competitiveness in the long term. Product Service Systems (PSS) is a specific type of value proposition that a business offers to (or coproduces with) its clients [1]. PSS provides structural reforms to facilitate sustainable production and consumption [2] as well as a significant impact on reducing the use of resources [3].

The potential benefits offered by PSS provides integrated solutions that have an impact on environment,

social, and economic, which enable the company to optimize resource utilization and increase its competitiveness [4]. Researchers have also developed a methodology for designing PSS [5]. At design stage and integration of PSS, designers created a design concept in detail and the integration of stakeholders involved. Relations between the stakeholders described in detail in the PSS blueprint [6]. However, these previous studies have not considered the requirements of multi-actor involved in PSS. Multi-actor such as customers and providers are important to be considered in the development and success of the PSS. On the other hand, Duru et al. [7] developed an integrated approach in creating services. Duru et al. [7] used Fuzzy-AHP method to process the data and developed the concept of Multi-layer QFD in planning the development of the service by taking the multi-actor aspect into account. The study considers the needs of customers and providers in the development of the service. However, Duru et al. [7] did not consider PSS strategy. Therefore, Surjani et al. [8] adopted Multi-layer QFD for PSS development by considering the needs of multi-actor, as well as the multi-customer segment.

Besch [9] conducted research on the barriers and opportunities of PSS for office furniture and advised to find out the criteria for selecting products in order to run PSS successfully so that it can be used as a guideline for the furniture company to develop the PSS. Furniture trade has been growing rapidly worldwide in the last decade. It has been supported by innovations in distribution and knock-down packaging which are able to ease the worldwide trade [10]. On the other hand, as a result of the furniture development, there are concerns about the impact derived from the production environment and the question arises about the furniture life cycle [11]. Therefore, PSS designs for furniture needs to be examined.

PSS success is not only determined by PSS design process. Evaluation of PSS design has a very important role to support the success of the PSS. Yoon et al. [9] developed an evaluation model based on the viewpoint of the customer and the provider. Lee et al. [10] evaluated the development of PSS based on customer value and customer experience cycle.

Based on the background described above, an analysis of multi-actor will be performed in this research in order to get the interests of customers and companies

by using Fuzzy-AHP. Furthermore, a framework of PSS business model for furniture will be developed based on analysis of Multi-layer QFD and design evaluation of PSS.

II. METHODOLOGY

A. PSS Development

Product Service System (PSS) can be defined as a system that integrates products and services to meet the customers need [14]. PSS is generally classified into three categories, namely Product-oriented, Use-oriented, and Result-oriented. In Product-oriented (Po) PSS, the system is oriented in selling products as well as a commitment to provide services related to the product. In Use-oriented (Uo) PSS, the provider is not selling a physical product, but customers can use the function of the product, in which the system can be provided in the form of services and possible to be used in conjunction with multiple users. In Result-oriented (Ro) PSS, the provider provides products or services that customer needs but there are no products or services that are directly involved, only limited agreement between the customer and the provider [15]. In this study, the development of PSS for furniture will be focusing on the analysis of Product-oriented PSS and Use-oriented PSS. Use-oriented PSS analysis will be used for the furniture rental. A sample case is reported to exemplify the framework of PSS development for furniture.

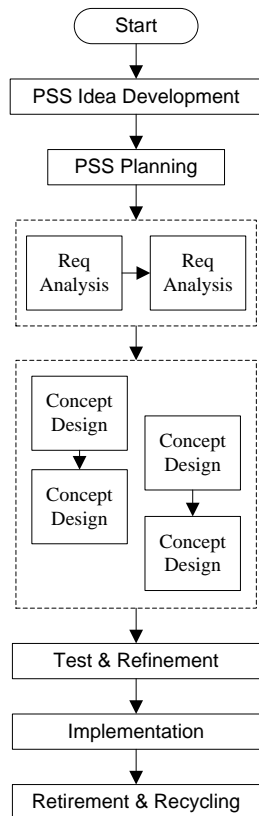


Figure 1. Systematic PSS Development
Source: Tuan & Joon [16]

In general, the development of PSS consists of seven phases, namely the development of PSS idea, PSS planning, requirement analysis, design and integration of PSS (concept design), test and refinement (evaluation), implementation, and retirement and recycling [16]. PSS development is described systematically in Figure 1. At this stage of idea development, a PSS designer needs to analyze the internal and external environment surrounding the market opportunities, the business model of PSS, and PSS categories that will be developed. In the planning stage, PSS designer needs to plan resource allocation, market segmentation, and scheduling of PSS. In the requirement analysis stage, designer needs to identify customer needs, benchmarking, and specifications of PSS. A clear understanding of customer needs is very important.

TABLE 1.
GENERAL NEED

Variable	Aspect	Description
Provider's Requirements ^a	Costs	Price (cheaper)
		Cost of operation (less costly)
	Finance	Cost of financial support (less costly): Bank finance, leasing, syndicated loan etc.
	Operation	Ease of maintenance
		Ease of operation
		Quality of equipment
	Design	Durability
		Existing design
Customer's Requirements ^b	Purchase	Low cost to buy or use
		Ease of purchase
		Information on product/service life cycle
	Use	Various functions
		Pro-environment material
		Pro-environment resource
	Use Disposal	Resource reduction
		Customized use
		Optimized use
		Best performance
		Low maintenance
		Flexible use
		Long use
		Stable use
		Ease of use
		Availability beyond space and time
		Additional value creation from use
Pro-environment disposal		
Ease of disposal		
Additional value creation from disposal		

Sources: ^{a)} Duru et al.[7], ^{b)} Kim et al.[1]

Kim et al. [1] provided a reference scheme for PSS models that can help PSS designers in solving the needs of customers in general. Kim et al. [1] have identified a general need of PSS from customers outlined in Table 1 and the services that could be developed for the development of PSS in Table 2 (PSS models). In the design phase and the integration of PSS, designers create a design concept in detail and integration between stakeholders involved. Relations between the stakeholders

described in detail in the blueprint PSS [6]. PSS blueprint is defined as a map that describes the system of products and services in integrated and systematic way to provide increased value and sustainability. In PSS blueprint, it is explained that PSS consist of three main areas, namely the product area, service area, and supporting area as shown in Figure 2. PSS Evaluation can be obtained from a test implementation or feedback from customer. Next, PSS development can be continued through retirement and recycling on end of life PSS.

TABLE.1.
PSS MODELS

Criteria	Description
Recycle service	Reuse, reutilize, recondition, or remanufacture products
Maintenance service	Repair and maintain the product/service
Capital budgeting service	Provide financial service for customer's capital budgeting
Diagnosis service	Monitor and diagnose the condition of the product/service in use
Information service	Provide customer with necessary information on the product/service during its life cycle
Consultation service	Provide customer with professional knowledge or advice for the optimal use of the product/service.
Education service	Educate and train customer on the product/service
Installation service	Install or assemble product for customer.
Agency service	Conduct work for customer
Life cycle service	Provide a series of services during the product/service life cycle
Total package solution	Provide a "one-stop package solution."
Trial Service	Provide customer with trial versions or opportunities to experience the product/service temporarily
Customized solution	Provide products/services customized for the specific needs or environment of the customer
Sale by component	Sell components or parts of the product/service in anticipation of repair or upgrade requests from customer
Expansion of access	Create and offer new ways for the customer to access the products/services

Source : Kim et al. [1]

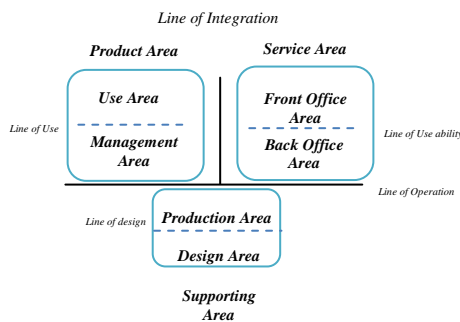


Figure 2. Structure of PSS Design Blueprint
Source: Geum & Park [6]

B. Multi-layer QFD

Research of product development which considers customer and provider requirement was examined in a

Multi-layer model of QFD [7]. Multi-layer QFD is modeled in three dimensions that describe HoQ (House of Quality) from customers, HoQ from providers, and cross-synthesis of the customer and the provider. Figure 3 illustrates the Multi-layer structure of QFD. The anterior surface of the cube shows the original HoQ matrix which is oriented on the needs/satisfaction of customer. On the right side of the cube is the HOQ matrix oriented towards provider needs/satisfaction. The term of customer needs/satisfaction is indicated by edge#1, while provider needs/satisfaction is indicated by edge#2. Furthermore, technical response is obtained from both identical matrixes (edge # 3). The top of the cube shows a matrix of cross-synthesis for conflict resolution. The size of the cross-synthesis matrix is based on the requirement of both elements (providers and customers). Multi-layer QFD is used to investigate the relationship between customer and provider needs. The importance level of criteria is defined by using Fuzzy-AHP. The result of relative importance level of each criterion will be calculated with each other. Evaluation of cross-synthesis analysis synthesis concludes with the average of relative importance criteria of each actor.

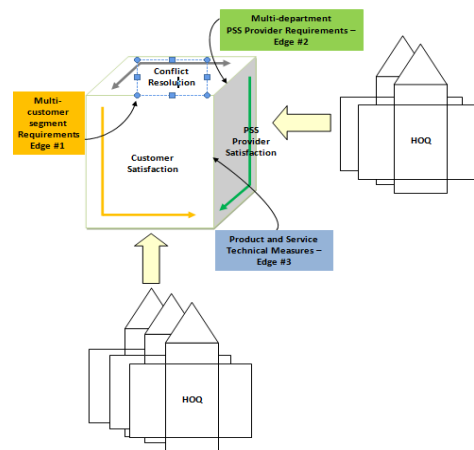


Figure 3. QFD Multi-layer QFD with multi-segment
Source : Surjani et al.[8]

C. PSS Evaluation

To achieve success of PSS, PSS evaluation should be considered by taking the viewpoints of providers and customers into account [9]. Evaluation from provider perspective related to potential risks during PSS design is to confirm the high probability of success. Evaluation from customer point of view is referring to the responses and preferences of potential customers. Table 3 exhibits the criteria of the provider and the customer.

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EVALUATION CRITERIA

Variable	Criteria	Source
Provider need	Economic	Yoon et al, 2012
	Technology	Yoon et al, 2012
Customer need	Efficiency Cost	Lee at al, 2015
	Efficiency Time	Lee at al, 2015
	Service	Mert at al, 2014

III. RESULTS

The rating of importance level of customers' needs for furniture product and customers' preferences towards services based on customer segmentation is obtained from the survey. Based on the importance criteria assessment of multi-actor general need and based on the assessment of provider's importance level obtained from the CEO of the company (from the assessment in Table 1 and Table 2), the selected criteria are obtained from Fuzzy-AHP calculation. Furthermore, cross-synthesis is analyzed and HoQ Multi-layer QFD is developed for each actor.

The result of previous analysis produces a HoQ Multi-layer QFD, which is furthermore used as an input in the design of PSS. The HoQ template for customer of furniture PSS is presented in Figure 4, and the HoQ template for provider of furniture PSS is presented in Figure 5. Customer and provider synthesis matrix is utilized to identify product and service criteria that will be developed. Design selection criteria template from synthesis matrix for Product-oriented and Use-oriented PSS is presented in Figure 6. Afterwards, the conceptual model of each PSS business model is identified according to the needs of customer and provider. From this design concept, PSS blueprint is formed based on PSS model that corresponds to the needs of customers and providers. PSS blueprints for PSS Product-oriented and PSS Use-Oriented are described in Figure 9 and 10.

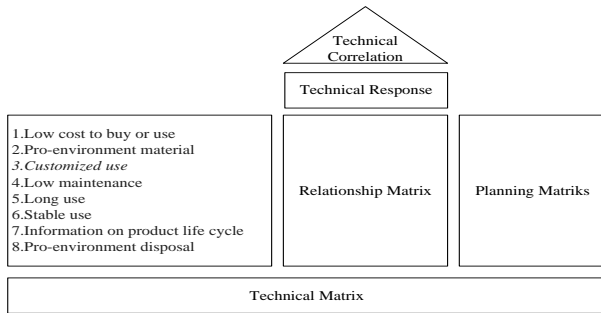


Figure 4. HOQ template for Customers of PSS

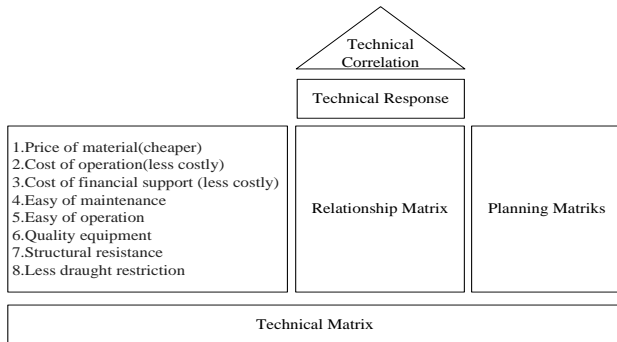


Figure 5. HOQ template for Provider of PSS

Evaluation based on each other's viewpoint, among others, related to the economic feasibility assessed based on the cost of investment, market size and growth analysis. Technological feasibility assessed based on the ability of companies to solve operational problems.

Evaluation is also based on a customer's perspective that is associated with the ability to get the product/service and cost-efficiency, the ability to get the product/service with time-efficient, and standard operation procedures (SOP) to get their products and services.

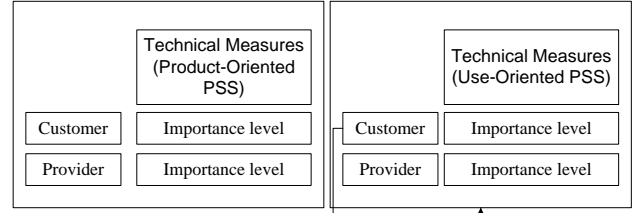


Figure 6. Design selection criteria template for Product-Oriented and Use-Oriented PSS

IV. DISCUSSION

Furniture faced several problems during its life cycle, such as termite, damage of components, aesthetic changes, etc. Furniture users require special handling to solve the problem. Furniture users also face challenges during housing transfer process, as it would require the process to relocate/reinstall furniture to new house. Furniture company has an opportunity to provide services such as maintenance, repair, and diagnose (termite and fumigation), installment, and sale by component. Whenever the customers encounter a problem related to their furniture, consultation can be conducted to discover the possible solutions which can be performed by the service provider. Conceptual model for Product-oriented is represented in Figure 7

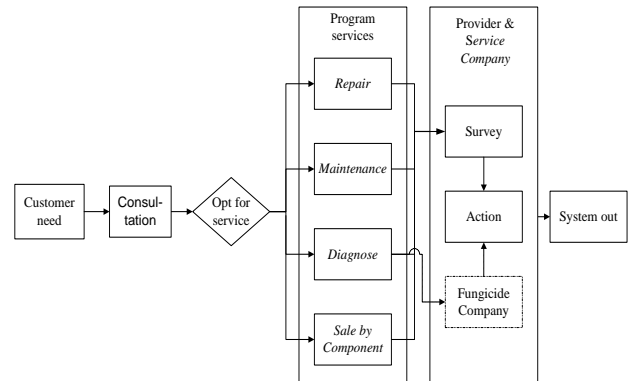


Figure 7. Conceptual Model of Furniture Product-oriented

The increasing number of population has implications for the residential needs. On the other hand, lifestyle and mobility change quite dynamically which also influence the needs of furniture. One of examples which show rapid changes on furniture demand is the furniture for infants. In line with its development, furniture for various ages of babies is required by the market. Another example is the needs of families who have a sedentary job. The house and furniture would not be needed in a long run. This situation provides an opportunity for the furniture company to develop the idea in the form of furniture

renting. Figure 8 describes the conceptual model for furniture renting as a business model of PSS oriented use.

The relationship between actors network and Standard Operation Procedures (SOP) to obtain the products and services is described by PSS Blueprint, shown in Figure 9 and Figure 10. The flow of PSS blueprint can be started from customer area, management area or production area. For example, in the PSS blueprint for Product-oriented, from customer area with the case of furniture upgrade service, the process flow is consultancy (1.1), upgrade service (2.2-2.5), preparation and action by provider, and then the customer can get and reuse the furniture. Next, in the PSS blueprint for Use-oriented, the order from customer is served by customer service and then responded by management area when the product has been ready. Afterward, the customer can get the furniture, finish the registration and payment.

Development PSS business model has its own character. The chance of success in implementing PSS business model is also affected by the character of customers. PSS Use-oriented model for furniture is likely to have a greater opportunity to be developed towards B2B strategy. The evaluation of this PSS business model provides an opportunity to increase the company's revenue along life-cycle through a service strategy that is offered. This opportunity should be supported by a huge marketing effort to gain market size since this is a new business model. The readiness of company's technology must also be prepared to encounter the complexity of PSS system. In the model of furniture renting, the company develops a Standard Operation Procedures (SOP) that can accommodate the needs of customers. In addition, the company has the opportunities for innovation and market development, to increase the operating efficiency, to improve relationships with customers, to increase corporate identity, to ease the collection of feedback related to the customers' needs. Through the development of the service, company can create job opportunities which would contribute to the reduction of unemployment. From the customers' point of view, PSS enables the customers to get services which are flexible to meet their needs and to get good quality of products and services.

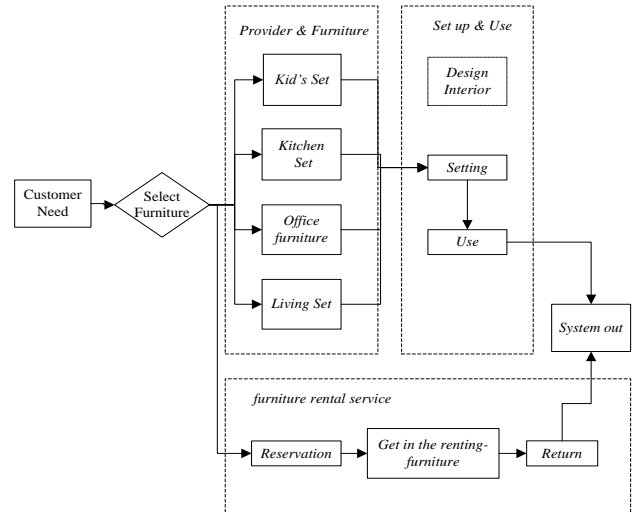
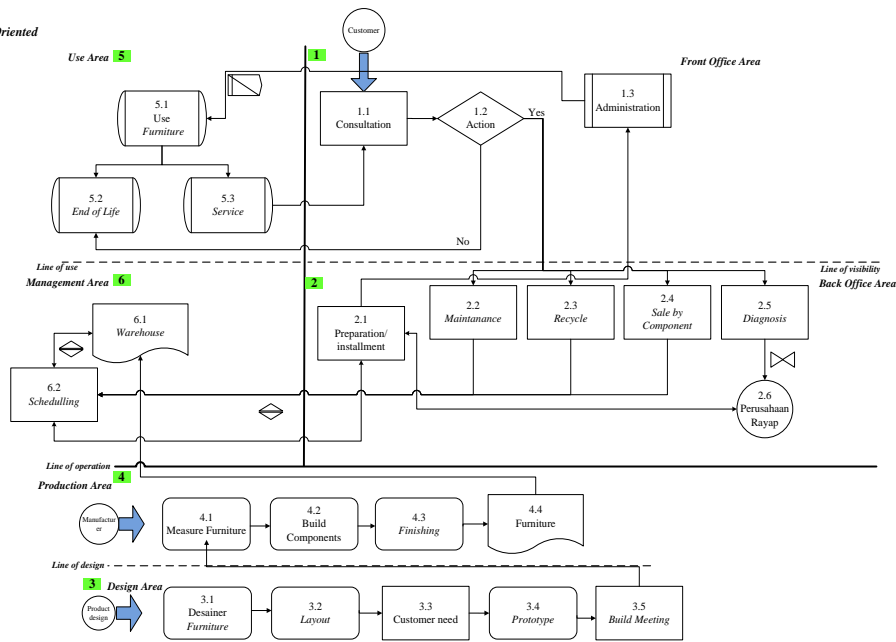


Figure 8. Conceptual Model of Furniture Use-oriented

V. CONCLUSION

This research generates important criteria from both customers and companies in the development of PSS furniture by utilizing the framework of Multi-layer QFD and Fuzzy-AHP method. The framework of PSS design strategy based on HoQ from Multi-layer QFD and PSS evaluation based on the perspective of customers and providers can be recommended as a program to improve the competitiveness of the furniture company. PSS concept offers potential that could provide a change in production and consumption patterns with implications for sustainability, as practical benefits for the company, customers, and environment. Development and evaluation of PSS can be made as a reference in arranging a business model development. The analysis of framework in this research could provide consideration to the implementation of PSS for furniture company which is expected to open up opportunities in pursuing a strategy to enhance the competitiveness of companies.

Product Oriented



Description:

i.From Customer:

1.1-1.2-3.1-3.2-3.3-3.4-4.1-4.2-4.3-4.4-6.1-6.2-2.1-1.3-5.1
for upgrade service system :
5.3-1.1-1.2-(2.2-2.3-2.4-2.5)-2.1-1.3-5

ii.From Management

6.1- 1.1-1.2-2.1-1.3-5.1

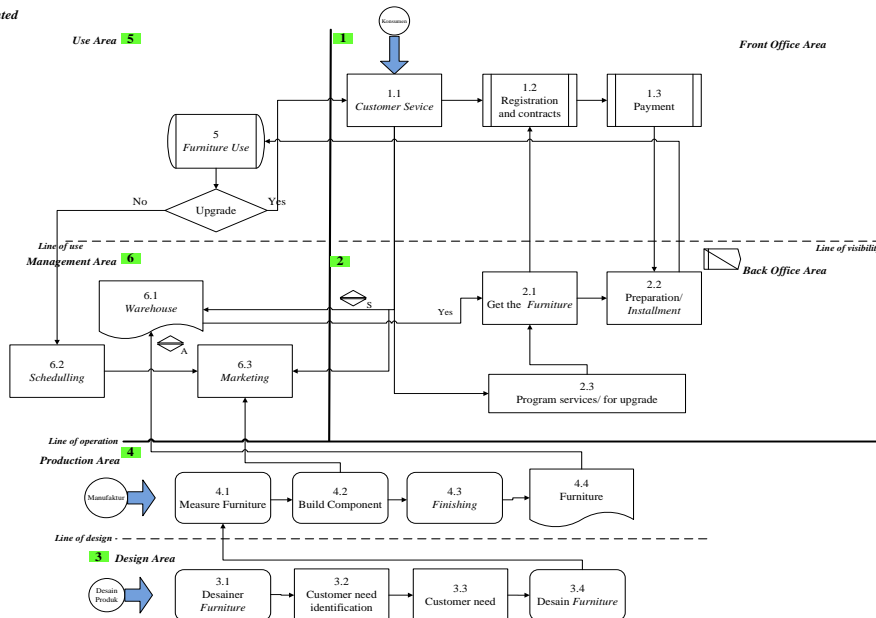
iii.From Production

3.1-3.2-3.3-3.4-4.1-4.2-4.3-4.4-6.1-6.2-2.1-1.3-5.1

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Figure 9. PSS Blueprint for Product-oriented Furniture

Use Oriented



Description:

iv.From Customer:

1.1-6.1-2.1-1.2-2.2-1.3-5
for upgrade service system :
1.1-2.3-2.1-1.2-2.2-1.3-5

v.From Management

6.1-6.2-6.3-1.1-1.2-2.2-1.3-5

vi.From Production

3.1-3.2-3.3-3.4-4.1-4.2-4.3-4.4-6.1-6.2-6.3-1.1-1.1-1.2-2.2-1.3-5

Figure 10. PSS Blueprint for Use-oriented Furniture

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