Conceptual Product-Service System CAD - An Application

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Abstract
Product-Service System (PSS) provides an enhanced view about the functional aspects of value creation. Manufacturers are increasingly transforming their whole systems including processes in order to support the provision of PSS throughout its lifecycle. Substantial changes in terms of methods, tools and software is required to develop PSS in a structured manner due to its peculiar properties. This research aims to develop a software platform which will aid the development process of PSS. In this paper, merits and limitations of Service CAD (a non-commercial software) as a PSS development tool are discussed. A demonstration of PSS development is done through the use of a laser systems case study. In so doing, necessary modules which are required to enhance the Service CAD are identified and one of the modules is programmed as an enhancement to the software.

Keywords:
Product-Service System, Design, Software

1 INTRODUCTION

The functional aspects of value creation are gaining considerable importance in today's competitive business to business environment. The emphasis is on the 'sale of use' rather than the 'sale of product'. Lower costs and long term relationships with the customers are considered as the primary factors for sustained business. In this context, an integrated product and service offering that delivers value in use provides this competitive advantage which has been commonly termed as Product-Service System (PSS). Goedkoop et al. [1] state that 'a product service-system is a system of products, services, networks of players and supporting infrastructure that continuously strives to be competitive, satisfy customer needs and have a lower environmental impact than traditional business models'. Meier et al. [2] define an 'Industrial Product Service Systems' (IPS^2), as an integrated product and service offering that delivers value in industrial applications. It has also been defined as a 'self-learning' system, one of whose goals is continual improvement [3]. A major perspective of this concept is to consider the system as a whole, rather than just physical products [4]. It aims to provide required customer value through reduced cost, optimized resources and sustained production. The major merits for the manufacturer of this approach are increased revenue, prolonged and strategic relationship with the customer and product/service improvements based on the improved understanding of customer usage and requirements.

Even though PSS provides substantial benefits to the stakeholders involved in the business, generally manufacturers are holding risks which were previously hold by customers. Therefore PSS needs to be designed carefully considering all the possible scenarios to avoid pitfall. Also the manufacturer's core competences are moving away from manufacturing to systems design and integration. The manufacturer needs substantial support in this process of designing PSS concepts in terms of methods, tools, techniques and software. Even though industries are offering PSS solutions for many years, the process of designing these concepts are ad hoc. In academia, various methodologies and software are proposed in the recent years. But these propositions are in a preliminary stage and require substantial validation to achieve significant benefits to the industries in structuring the process of PSS development. Besides, it is important to note that the aims and objectives of these proposed design methodologies and tools differ extensively.

This research aims to develop a software platform to assist industries in developing PSS concepts in well-ordered fashion. In this paper, features required in an ideal software platform are identified and discussed. To identify the ideal software platform, currently available non-commercial software and methodologies proposed in literature are reviewed and analysed accordingly. To facilitate an in-depth understanding of the required features, an example problem is formulated and applied to Service CAD software developed by Komoto and Tomiyama [5]. Explanation of PSS concepts development for laser systems case study has been detailed through Service CAD. These illustrations help to propose necessary enhancement modules required in the PSS concept development software. One of the modules is programmed in Service CAD and demonstrated.

The rest of the paper is structured as follows: Section 2 discusses and analyses various PSS design methodologies proposed in literature and software platform developed to support PSS concepts development, Section 3 details the example laser case study problem and application to Service CAD, Section 4 elaborates the enhancement modules required to augment the features of Service CAD and describes an implemented module and Section 5 concludes with conclusion and future work to be carried out.

2 LITERATURE REVIEW

In this section, PSS design methodologies proposed in literature are analysed and discussed. Emphasis has been provided to the methodologies which have been implemented through software to generate PSS concepts. By doing a literature review, we aim to understand the required features highlighted in the methodologies and incorporated in the software platforms. Studying across the methodologies helps to summarize the important features needed in the PSS concepts development. This section concludes with the gaps identified to improve the overall development process.

Komoto and Tomiyama [5] proposed Service CAD which supports designers to generate conceptual design of PSSs. They argue that in PSS design process, designers define activity to meet specified goal and quality, and define environment, under which the activity is realized. The elements used in Service CAD are service environment, provider, receiver, channel, contents, activity, and aim of the service receiver's activity, target, promised goal, realised service, quality and value added. They also developed ISCL (Integrating Service CAD with a life cycle simulator) which has functions to support quantitative and probabilistic PSS design using life cycle simulation. Figure 1 illustrates the architecture of Service CAD.

Shimomura et al. [6] aim to propose a method for designing service activity and product concurrently and collaboratively during the early phase of product design. To enable this designing, a unified representation scheme of human process and physical process in service activity is proposed. They expressed a state change of a customer by parameters called Receiver State Parameters (RSPs), which represent customer value. They propose a view model which handles functions and attributes to represent RSPs. They include three phases in service design process: identifying customer value, design of service contents and design of service activity. They also developed a method to evaluate these processes with Quality Function Deployment. Sakao et al. [7] developed a service model consisting of four sub-models: flow model, scope model, scenario model, and view model. They emphasize that the critical concept is not the function of a product, but rather the state change of the receiver. The state change can be fulfilled either by products or by service activities.

They have implemented these models through prototype software named Service Explorer. Figure 2 illustrates the conceptual structure of Service Explorer. Welp et al. [8] argue that an Industrial PSS (IPS²) can be made up of any combination of product and service mix. They propose that the IPS² concept development is responsible for generating principle solutions that meet customer specific requirements. They present a model based approach to support an IPS² designer generating heterogeneous IPS² concept models in the early phase of IPS² development. They frame three planes for systematic conceptual development: IPS² function plane, IPS² object plane and IPS² process plane. The combination of all three modelling planes constitutes a heterogeneous IPS² concept model. Three different types of model elements are defined: system elements, disturbance elements and context elements. The combination of all types of model elements and their respective relations constitutes a heterogeneous IPS² concept model.

Apart from these three methodologies implemented in software, there are many methodologies proposed in literature for PSS development. The rest of this section discusses these proposed methodologies to highlight the features mentioned. Maussang et al. [9] consider the whole system and detail the physical objects and service units necessary to develop a successful PSS. They argue that this methodology can support the design of PSSs from the design of the architecture to the identification of physical object's (products) specifications. They used operational scenarios to elaborate the system description once main elements of the system (physical objects and service units) have been identified. External functional analysis is used to list the functions that the customer and the actors involved in the product lifecycle expect from the product without considering elements available to provide them. They argue that a specific external analysis must be carried out for each step of the product life cycle (use, manufacture, maintenance, recycling, etc.). They characterize each function or constraint by criteria, level and allowance. They argue that this characterisation leads to the elaboration of specifications and product performance expected by the customer.

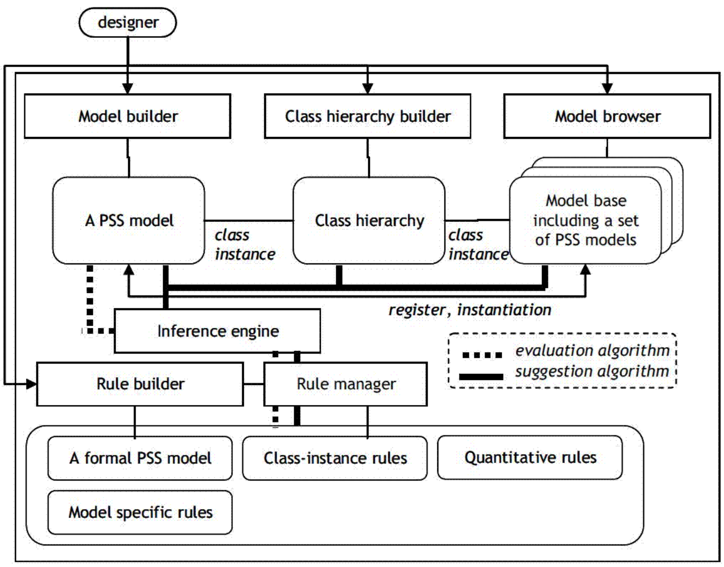

Figure 1: Architecture of Service CAD [5].

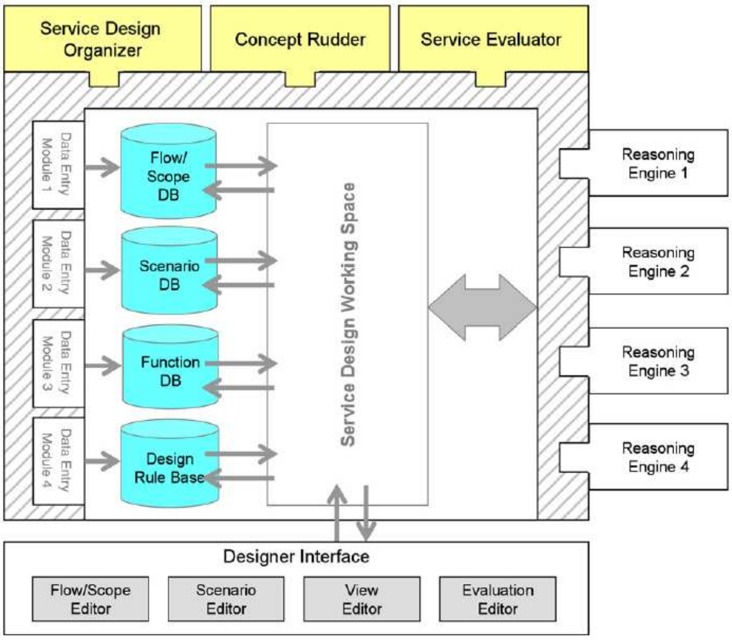

Figure 2: Conceptual structure of Service Explorer [7].

Aurich et al. [10] introduce a process for the systematic design of product related technical services based upon its modularization to link with corresponding product design processes. They propose an Object oriented technical service model to support the specification of technical services during their actual designing. The service components mentioned in the model are: the component description provides a general overview of a technical service both verbally and graphically; the component reference covers the description of the products, product components or users' profiles addressed by the technical service along with the intended effects on them. The component function describes the measures for realizing the service functions and the component resources covers both physical and nonphysical resources necessary for realizing a service. They developed a systematic service design process to specify technical services according to the presented service model. They suggest that adapting already existing product design processes to account for the special characteristics of technical services would lead to maximum acceptance for application within the enterprise.

Alonso-Rasgado et al. [11] described a design process for Total Care Product (TCP) creation that integrates hardware and service support by providing a robust design methodology. The fast-track design process consists of a methodology that breaks down the iterative process between customer and supplier into a number of distinct stages necessary for the creation of the TCP. Fast-track design process is framed as: business ambitions of the client, potential business solutions, enhanced definition of the potential TCP, business case risk analysis of options, business case validation and evaluation of alternatives and contract. They consider two main variables of the system in simulations: (1) time taken to perform the service and (2) the quality and flow of information within the system.

Muller et al. [12] proposed a method for the development of PSS called PSS Layer method. This method intends to apply in early development phases comprising the clarification of the design task and the conceptual design phase. It defines a meta-model of nine main element classes for a PSS. The classes are: needs, values, deliverables, actors, lifecycle activities, core products, periphery, contract and finance. All classes are graphically layered to simplify the representation. They argue that this model provides the user to get a structured outline and the big picture of PSS idea or concept.

From the summary of literature, it has been noted that many factors are intertwined and influencing each other in the PSS concept development. These features need to be appropriately modelled to visualize and understand the impact of these factors to each other and to the overall performance as a whole. The important features necessary in developing PSS concepts that are stressed in the above discussion are summarized below:

- Understanding integration and impact between products and services are highlighted in most of the proposed methodologies.
- The support system provides modelling environment to describe activities, environmental, disturbances and contextual elements.
- Service CAD intends to support PSS designers through rule specification and generation.
- The modelling platforms stress the importance of specification through needed values and describe state change of the customers.
- Importance of reasoning the specified specifications has been emphasised.
- Modelling stakeholders and their relationships has been noted.
- Intention to model from the architecture level to specific product and service features is observed.
- Functional analyses to map between physical products and services are specified.
- Modelling through scenario development is emphasized.
- Graphical representation is emphasised in the modelling environment which includes qualitative and quantitative descriptions.
- Generation and evaluation of PSS offerings are mostly considered in the methodologies. Especially simulations through quantitative and probabilistic approaches are stressed.
- The approaches majorly based on system perspective.

Software / Representation features	Service CAD [5]	Service Explorer [6]	OPCAT [13]	CAM [14]
Defined ontology – Clear syntax and semantics	Ambiguous	Ambiguous	Clear (not specific to PSS)	Clear (not specific to PSS)
Check syntax and semantics	No	No	Yes	Yes
Complexity handling through abstraction layers and managing subsystems interactions	Limited	Limited	In-zooming and out-zooming, Folding and unfolding, State expressing and suppressing	Nest the sub-processes
Creating views for different stakeholders	No	No	Yes	No
Integrates function (what the system does or designed to do), behaviour (how the system changes over time) and structure (how the system is constructed) aspects of the system	No	No	Yes	No

Table 1: Comparison of key features to support representation

Some of the gaps identified from this literature summary are as follows:

- It is seen that the driving factors (risks and uncertainties) of PSS are not properly modelled.
- Only few methodologies stress the importance of co-creation between stakeholders and feedback loops between the steps involved in the process.
- Roles of the stakeholders involved in designing PSS offerings are not clearly defined in the methodologies. Especially capabilities of the stakeholders are not considered during design stage.
- In-depth solution description to represent PSS concepts is not elaborated. This solution description should inform contract formulation which will be the final step to establish the link between the stakeholders.
- Sensitivities of the resources involved in the PSS concepts are not appropriately represented.
- Even though evaluation approaches are proposed, detail cost modelling to evaluate PSS concepts is not described.
- Incorporation of lifecycle activities for adaptation of the PSS concepts are not modelled in the proposed methodologies.
- Representation techniques used in the modelling are not yet adequate to show the complexity involved in PSS.

These points illustrate that in order to develop a robust PSS concept considering the emerging risks and uncertainties; a sophisticated platform is needed which will incorporate various additional features and that platform is lacking in the extant literature. To understand some of the issues highlighted here, the next section demonstrates the application of a software platform through a laser case study example.

2.1 Representation comparison

Current software packages involve complex network structure to analyse the whole system. Representation should be structured and layer based approach can be used to avoid complexity. Co-creation between the customer, the manufacturer and the suppliers plays an important role in the design and provision of PSS. PSS models should represent stakeholders, products, services, business elements, work flow, business processes and interactions amongst them.

To aid the process of co-creation, the representation of PSS should be unambiguous, consistent, simple, complete, extensible, intuitive, easy to interpret and easy to maintain. In this section, comparison between various software (Service CAD [5], Service Explorer [6], OPCAT [13] and CAM [14]) which could be potentially used in PSS domain is carried out. OPCAT is commercially available software aims to turn concepts, cross-system processes, functions and requirements into a coherent, consistent blue print.

Cambridge Advanced Modeller (CAM) is a software tool for modelling and analysing the dependencies and flows in complex systems - such as products, processes and organisations. Even though OPCAT and CAM are not intended to support developing PSS concepts, they help to understand current state-of-the-art in representation techniques. Table 1 illustrates the comparison of key features to support representation in the PSS development. It highlights that commercially available software (OPCAT) addresses important issues in the representation. These state-of-the-art techniques need to be incorporated in the PSS development platforms. In specific, the challenges involved are: modelling the capabilities of stakeholders, the representation of qualitative factors, the integration of logical, operational, behavioural, temporal and physical processes involved in PSS. Certainly, the models should represent the value created by the developed offering and depict the risks associated with it.

3 AN APPLICATION ILLUSTRATION

To understand the merits and limitations of the software in-detail, an example problem is framed and implemented in Service CAD [5]. The rest of this section is structured by describing the exemplar problem, implementation through the software and the results obtained.

3.1 Problem definition

Based on the spectrum of product and service mix in the offerings, PSS has been commonly classified into three types: Product Oriented, Use Oriented and Result Oriented. This classification is based on product ownership and functionality, business models and product and service substitution. The example illustrated in this section falls in the type of Use Oriented PSS.

The problem description for PSS could be focused from different perspectives based on the respective stakeholders. In this paper, the focus is from the manufacturer who integrates and provides functionality of laser system as a complete unit to the laser job shop which then produces machined parts through laser cutting for the end product manufacturer. Figure 3 illustrates this value chain in the laser industries.

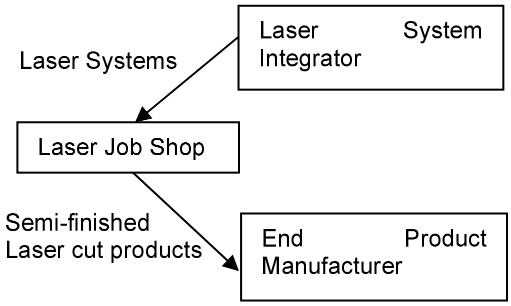

Figure 3: Value chain in the laser industries.

Rather than procuring the laser system from the manufacturer, currently the laser job shop intends to move to another business model of Use-Oriented type. In this functional oriented type, the laser job shop will specify the required level of Overall Equipment Effectiveness (OEE) for the laser system. Equation 1 illustrates the measurable elements used to calculate OEE.

OEE = Availability x Performance x Quality (1)

The priorities for these measurable elements could be different for different laser job shops. In this example, the priorities are kept equal for all the elements. Equations 2-4 describe the measurement of individual element.

Availability = MTBF / (MTBF+MTTR) (2)

MTBF: Mean time between failure

MTTR: Mean time to repair

Performance = Working speed / Designed speed (3)

Quality = Good units produced / Total units produced (4)

The expectation level of OEE for the laser job shops is usually above 75%. The PSS offering requires the manufacturer to satisfy an OEE level well above 75% for five years in fixed cost. This is a challenge which needs to be addressed at the development stage of PSS. OEE is influenced by many factors involved in the manufacturing operations.

In this problem, it has been assumed that OEE is influenced by maintenance activities conducted by the manufacturer.

Planned, preventative and repair are the maintenance activities considered in this formulation. Planning these maintenance activities is an important task which influences total costs incurred by the manufacturer to provide the functional benefit to the laser job shop by maintaining OEE greater than 75%.

In the PSS design problem, for supplying 100 laser systems to the laser job shops through this business model, the manufacturer needs to identify answers for the following questions:

- How planned, preventative and repair maintenance activities influence OEE?
- How much maintenance man-days are required to support this business model?
- What will be the total maintenance costs incurred in this model?
- What will be the best fixed price / month for this business model?

Answering these questions through Service CAD [5] is illustrated in the next section. It should be noted that Service CAD is used as a design support tool rather than doing design itself.

3.2 Implementation in Service CAD

In this section, modelling of the illustrated problem in Service CAD is done and simulation carried out to answer the framed questions is described. As mentioned in Section 2, the first step carried out in modelling is to define activities to meet specified goal and quality, and define environment, under which the activity is realized. Figure 4 illustrates the modelling environment developed for the problem described in Service CAD. Emphasis has been provided to the manufacturer and the laser system. The activities considered are produce, sell, use, planned, preventative and repair maintenance. The environment is limited to the manufacturer, the laser job shop and laser system. The goals are represented through total costs and OEE for the manufacturer and the laser system respectively. In order to track the measurable elements in the laser system; availability, performance and quality are individually modelled through quantitative levels of 90, 70 and 50 respectively. Table 2 illustrates conditions and consequences for each activity to describe the proposed problem. The conditions specify the rules that are necessary for the particular activity to be executed. The consequences describe the impact of that particular activity on the environment after execution.

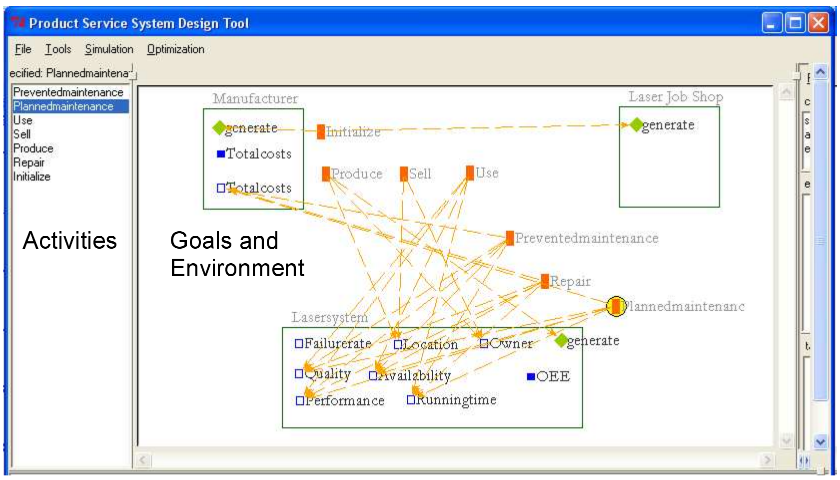

Figure 4: Modelling environment developed for the problem in Service CAD [5].

Activity	Conditions	Consequences
Produce	[Manufacturer, production facility, product design]	[Generate(Laser system [100]), Availability, Performance, Quality: 100, Owner (Manufacturer, Laser system), set(place(Laser system), Manufacturer]
Sell	[Manufacturer, Laser job shop, Laser system, owner (Manufacturer, Laser system)]	[Owner(Manufacturer, Laser system), set(place(Laser system), Laser job shop] [100]
Use	[Laser job shop, Laser system, state(Laser system, Operational)]	[Random(Availability: -9, Performance: -8, Quality: -8, set(OEE(Laser system)), Running time: +1]
Planned maintenance	[Manufacturer, Laser job shop, Laser system, Running time (Laser system, Once in six months)]	[Man-days:+2, Random(Availability: +5, Performance: +10, Quality: +10), set(OEE(Laser system)), Total cost: +£500]
Preventative maintenance	[Manufacturer, Laser job shop, Laser system, (Random (Running time) and OEE < 90)]	[Man-days:+1, Random(Availability: +5, Performance: +5, Quality: +5), set(OEE(Laser system)), Total cost: +£700]
Repair maintenance	[Manufacturer, Laser job shop, Laser system, Random (Running time)]	[Random (Man-days: +2-4), (Availability: +5, Performance: +10, Quality: +5), set(OEE(Laser system)), Total cost: +£300-800]

Table 2: Conditions and consequences for each activity.

Table 2 consists of short explanations but further explanation is not provided due to the word limitations. Activity sequence has been defined in the order of produce, sell, use, planned, preventative and repair maintenance activities. Modelling through the goals, activities and environment provides a clear picture about the focus of the system. Specifying conditions and consequences of activities help to define and understand the possible state changes happening within the environment.

It has been assumed in this problem that the laser system is at the initial release, so past performance data is unavailable. Randomness is used to generate the possible variation to represent the consequences of use, planned, preventative and repair activities. If sophisticated mathematical functions are available to represent the conditions and consequences, it could be easily incorporated in Service CAD [5]. Also it is assumed that the laser system is produced with 100% OEE.

3.3 Generated results

The simulation has been carried out for 100 times with each simulation accounts for one month of use. It has been noted in the complete simulation times that all laser systems are operational. Figure 5 plots the man-days required to carry planned, preventative and repair maintenance. The pointed line illustrates that after 50th simulation (i.e. after fourth year) substantial human resources (more than 80 people) are required to carry out the activities. Figure 6 represents the gradual depreciation of OEE values across simulation cycle. It shows that until the simulation cycle of 70, OEE has been maintained above 75% for all the 100 installed laser systems. It means that the current set-up is sufficient for the five years contract in fixed cost terms. Figure 7 illustrates the fluctuation of laser system availability values of 50, 70 and 90 respectively.

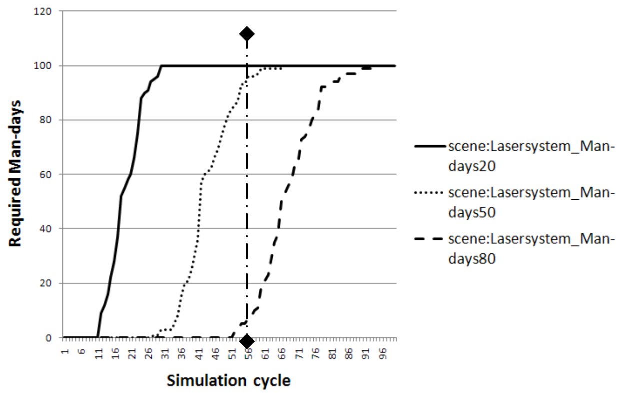

Figure 5: Required man-days.

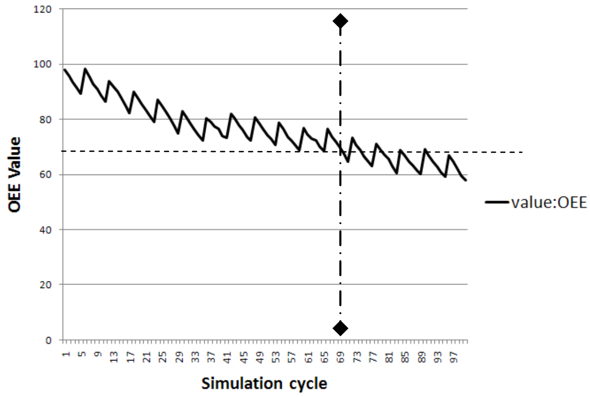

Figure 6: Depreciation of OEE values.

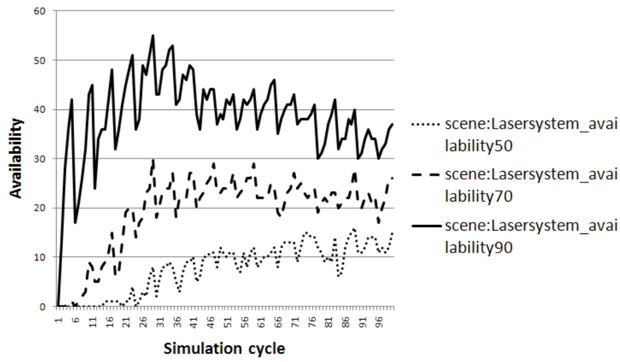

Figure 7: Fluctuation of laser system availability.

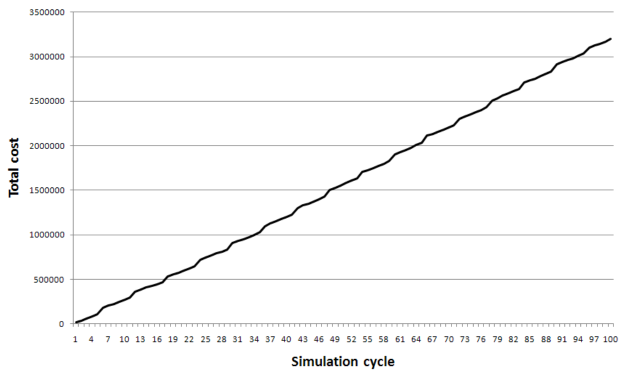

Figure 8: Linear progression of total cost.

Figure 8 depicts the linear progression of total costs incurred in these maintenance activities. This cost suggests that approximating £32K to each laser system could be the best price for carrying out these activities in the Use oriented PSS model. This cost does not include the capital and other costs incur during the business operations. These outcomes are obtained for one set of conditions and consequences of the activities specified. By varying the conditions and consequences in terms of availability, performance, quality, maintenance time interval, man-days required, incurred total cost and influences of running time, various PSS design solutions can be generated.

Plotting these curves through basic experiences would help companies to understand PSS business solutions and respective systems required to support these solutions. Various parameters such as maintenance interval time, availability of spare parts, time to diagnose the problems and adequacy of labour could be varied and their impacts to the overall system could be modelled and studied. For example, Figure 9 shows the influences between availability and maintenance interval period. It is possible to achieve certain level of OEE either by varying maintenance time interval or increasing the time interval between MTBF. The next section details the limitations in this approach and suggests enhancement modules to increase the capabilities of this software.

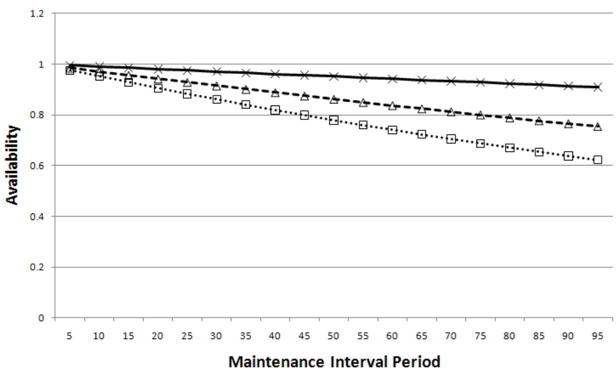

Figure 9: Influences between availability and maintenance period

4 SUGGESTION FOR ENHANCEMENT MODULES

Based on the literature review and in-depth analyses of Service CAD through application of a sample problem, various required enhancement modules are identified for a more systematic PSS development. In this section, these identified enhancement modules are listed and some of the modules are detailed:

- Problem definition

Currently in the existing PSS software platform, PSS problem description and solution representation are merged together. Even though Service CAD provides goal and quality to define the PSS problem, they are not separated with the design objects (activities, constituents, environment and parameters). Developing this problem definition module should support designers to get the information from the customers through structured format and could be translated into requirements and constraints. Understanding these constraints is vital in developing the solutions. The structured format could be in terms of reliability, maintainability, availability, flexibility, cost, time scale, performance and risk. Analysing currently available industrial service tender documents in business to business environment could provide more elaborative structure to this module.

Explicit and clear definition of PSS problems, help customers to articulate their needs and desires in a relatively more structured form. It also aids manufacturers to identify and evaluate superior solutions through which customer's actual needs are satisfied. It is commonly noted in product and service design research that 'needs' and 'desires' are not appropriately transformed into problem statements and requirements. Often problem statements are incomplete, inconsistent, imprecise and ambiguous. Even though problem statements will contain these characteristics during the initial stages of design, a holistic approach which considers the whole lifecycle is usually missing.

Based on our understanding through literature and analysing tender documents used in the industries to formulate the requirements, we have identified seven major factors that should be incorporated in the PSS problem definition.

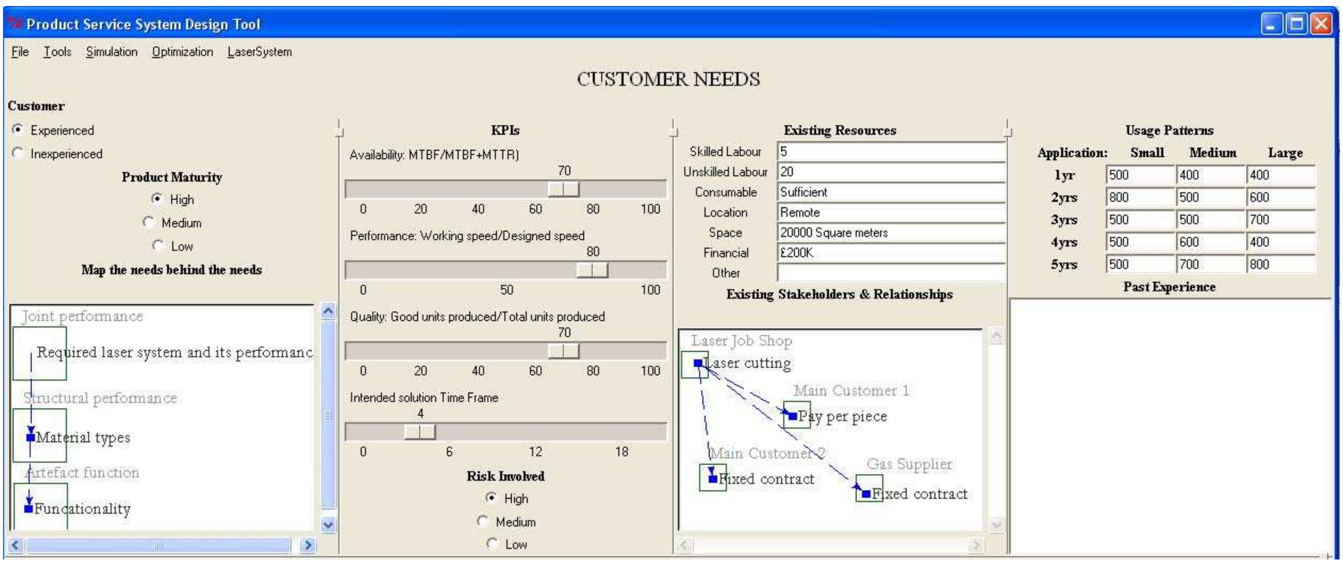

Figure 10: Problem definition module developed in Service CAD

These factors are detailed below with the laser case study example.

- Map the needs behind the needs: Customer needs and their respective rationale should be captured by mapping the needs behind the needs. For example, in laser job shop the needs behind the needs can be; minimum possible time to cut laser parts, to drawing errors and to end product manufacturer needs.
- Key Performance Indicators (KPIs): Measurable factors are important to develop well-built PSS solutions. Reliability, maintainability, availability, flexibility, performance, quality, cost, time scale, performance and risk could be some of the KPIs.
- Variation of usage patterns for the intended period: Functional aspects are largely related with the product usage activity and duration. Figure 10 represents this factor through matrix between years and size of laser machined parts.
- Experiences of the customer: Experienced customers would have the ability to answer the questions what they want and how they want it. In laser system case study, the laser job shop owners are very experienced in laser science and its application.
- Past occurrences in the business: Laser job shop owners could share the problems they face when using laser equipment such as time lost in fixing laser heads, cleaning optical parts etc which could help design better PSS solutions.
- Currently established relationships with suppliers and their customers: Since PSS covers a system level solution, understanding relationship between various stakeholders is vital. For example, the laser job shop has fixed contract relationship with gas supplier and pay per laser cut contract with their customers.
- Existing resources: Since the PSS solutions will be rest on the resources available with the customers, mapping existing resources is crucial. Resources could include skilled and unskilled labour, work space available, availability of consumables, shop location and financial strengths.

The first three factors help to understand the customer's needs and other factors help to understand the rationale behind these needs. Figure 10 illustrates implementation of this module through these factors in Service CAD. Explicitly specifying these factors at the initial stage would help to design better PSS business models and to develop systems to support these solutions. Among these factors, specifying the needs behind the needs, usage patterns and KPIs need better support. The validation of this module is currently ongoing with many testing PSS examples.

- Co-Creation modelling - Resource modelling, Stakeholder modelling, Supply network modelling

Co-creation process between the customer, the manufacturer and the suppliers plays a vital role in developing adaptable PSS solutions in a systematic manner. Capabilities of retaining, enhancement, and relinquishment between the stakeholders are the primary outcomes from the co-creation process. The main emphasis in this process is to bring in the customer's resources along with the manufacturer and suppliers to achieve beneficial outcomes. This brings resource modelling into the part of co-creation process.

It should be noted that the additional resources required to perform an activity needs to be extended. But in Service CAD, the activity will be terminated if the condition to match the resources fails. Partial matching of the resources and adjusting to the required performance will be the key elements to be modelled. Also sensitivity of the system should be evaluated by understanding the key influencing factors. This modelling will then continue go on to assign responsibilities between the stakeholders. This part also includes supply network assessment to assess the capabilities to support the developed solution.

- Product and Operational modelling

Since integration and impact between products and services are continuously discussed in literature, these characteristics need to be modelled structurally. Capability shifts between products and services need to be modelled. Failure scenarios and product environment need to be properly constructed. Generally functional, life cycle and failure frequency are modelled for products; and for services: types, combination, response time, technician's skills and frequency are modelled. Currently available software describes the processes, interactions, precedence and causality relations and conditions and consequences of the activities. But the complexity of influences between the activities is not appropriately addressed. This is linked to the representation structure and understanding of the impact generated by these linkages.

- Solution representation - Cost modelling

This module should demonstrate the complete solution generated for the stated problem. Current version of software platform lacks in defining the final solution. The solution should explain product and service characteristics, business model elements, activities to be carried out, required resources and interactions among them. The solution should be detailed enough such that it could be alternative for bid document which is a current industrial practice consists of solutions for the released tender documents. Also this module should represent variety of solutions and provides comprehensive comparison between them in terms of costs and other influencing parameters. This module should cover detailed cost modelling for the solutions through responsibilities and resources allocated between the stakeholders. Outcomes could be in the form of matrix of combinations between products and services (solutions) represented by cost for each solution which could lead to better evaluation and to take informed decision.

5 CONCLUSION AND FUTURE WORK

In this paper, merits and limitations of currently available non-commercial software are discussed and in-depth explanation of PSS concepts development for laser systems has been detailed through Service CAD. In the course of these analyses and comprehensive literature review on PSS design methodologies, various necessary modules required to enhance Service CAD are proposed. The proposed modules illustrate that there is a huge scope for advancement in development of PSS solutions. One of the modules, problem definition is programmed in Service CAD and its importance is demonstrated. Our future work aims to develop a software platform through conceptual design framework that addresses the capabilities and requirements of the service network and customer using a co-creation process.

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