An Approach to Manage and Evaluate Engineering Asset Performance

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Received: 16 December 2013 Accepted: 5 January 2014 Published: 15 January 2014

Abstract

Modern engineering assets are complex and very high in value. They are expected to function for years to come, with ability to handle the change in technology and ageing modification. The aging of an engineering asset and continues increase of vendors and contractors numbers forces the asset operation management (or Owner) to design an asset management system which can capture these changes. Furthermore, an accurate performance measurement and risk evaluation processes are highly needed. Therefore, this paper propose an asset management system performance evaluation for an engineering asset based on the System Support Engineering (SSE) principles. The research work explores the asset management system from a range of perspectives, interviewing managers from across an industrial organization. The factors contributing to complexity of an asset management system are described in context which clusters them into several key areas. It is proposed that SSE framework may then be used as a tool for analysis and management of asset with given an industrial example. The paper will conclude with discussion of potential application of the framework and opportunities for future research.

Index terms— engineering asset management, performance, evaluation.

1 Introduction

lassical techniques in asset management involve performance monitoring, process control and fault diagnosis techniques that aim to determine the limit of the asset's service life. Theoretically, replacement should be made at the time when a component of an asset is about to fail so that the full service value of the asset can be utilized. However, this is not possible as modern assets are increasing in complexity and sophistication. Moreover, many additional factors are always governing the management of the asset.

Modern engineering assets are complex and very high in value. They are expected to serve for years to come with ability to handle the change in technology and customers' demands. Literatures are showing that the consideration for the sustainment of an asset should be engaged at the very early stages of asset management system development. Asset stakeholders are demanding more value out of their asset by ensuring sustainability in operation. These include availability, readiness, extended operation and other value schemes. Literatures show that asset management industry is proposing a holistic asset management system approach (Herder & Wijnia, 2012; W. Lee, Moh, & Choi, 2012). However, the challenge is how to holistically evaluate the performance of the asset management, whether if it is in-house management or contracted management.

As the asset stakeholders intend (in some cases have) to outsource the support and asset management activities, the service provider will take significant part of the risk of sustaining capabilities of the asset for the duration of the service **??** In other words, the performance of the asset will relay or directly affected by service and support provider(s). It is to the interest of the asset owners and asset manager that the asset does perform as they wish. Hence, the relationship between the asset management stakeholders should be clearly drawn and understood in regard to the implication and the nature of performing together to get the most out of the system.

Asset performance measurements depend on good data that is analyzed with sound methods (Pecht, 2012) and be translated into information and knowledge allowing decisions to take place. Industry often complain of information overload and difficult to allocate. Asset managers complain that they do not have all the relevant information to make sound and well-informed decisions. To identify what parameters to measure, it is needed to first understand what to change to improve performance and subsequently, identify what are the measuring parameters. This paper is proposing a methodology to evaluate and calculate the performance of an engineering asset management system. This methodology was built on the principles of the system support engineering.

Benedettini, & Kay, 2009). Usually figures shows that 70-80% of the western economic activity is built on service (Wild, 2010). This economic figures stimulated researchers to innovate service systems. As a start, the basic principal of designing a compatible service system is a holistic view of the service where the customer's experience, technical and operational aspects of the product (Pang, 2009;Pombinho & Tribolet, 2012) is taking into account. One of the resent strategies in this regard is the servitization of a product. The main feature of servitization that it is bringing the focus of service system to a strong buyer centricity and resulted aim to generate value from both product and services in bundled packages (Ng, Parry, McFarlane, & Tasker, 2010). The combination of marketable product and service where can both satisfy the need of customer called product-service system (PSS) (Mont, 2002) and it can be provided either by single company or by an alliance of companies. There are over 100 existing articles about PSS in general (Sakao, Ölundh Sandström, & Matzen, 2009). In general, the literatures agreed that the focus of the PSS is to design market well-matched service for itemized product. Keeping in mind that the servitization developments were shifted form product oriented service to user process oriented and the nature of the customer interaction was shifted form transaction-based to relationship-based. These changes introduced new challenges for PSS functional design. Even with the PSS systemic approach, it has given diminutive depth consideration of elements of a service system or how the elements might interact. The foundation of Unified Services Theory (UST) has been drew as "With service processes, the customer provides significant inputs into the production process" (Sampson, 2010). The unified services theory delineates service processes from non-service processes (Dandan & Rongqiu, 2010). The UST is a distinctive process but it will introduce issues (i.e. structures, behavior, effectiveness, environment... etc.) and challenges on the service design process as the customers are vary around the world and they are operating in dissimilar environments for unrelated purposes. Literatures agreed in general that performance based contracting is a defined mechanism of rewarding values based on the measured outcomes which are scored and rated according to an agreement between two parties(Eldridge & Palmer, 2009; Hypko, Tilebein, & Gleich, 2010a, 2010b; Sultana, Rahman, & Sanaul Chowdhury, 2013). The concept of PBC is really unique and provides benefits to both parties of the contract. However, it did not give in depth details of systemic evaluation of the elements which constricting the performance body as it concentrated more on the contracting mechanisms understanding.

Performance measurement practices have undergone many innovations (Davila, 2012). Literatures shows that lots of these innovations have changed the relationships between organization and its employees, customers, suppliers and other stakeholders all to ward systemic approach.

System performance measurement did see a lot of these changes (Tonchia & Quagini, 2010b). Performance system requires specific measurements techniques using accurate performance indicators from the Performance Measurement System (Tonchia & Quagini, 2010a). Measuring performance has different perspectives include but not limited to accounting, marketing and operations. Finding performance is even being a new discipline in management (Neely, 2002). There are models for measuring performances. However, models developed in the last 20 years are more horizontal and process-oriented (Biazzo & Garengo, 2012).

This will lead to the following research question "Can industrial practitioners have a generic architecture to simplify the evaluation and sustainable evaluation of engineering asset performance?" If yes; how does it look like? This architecture can aligned all elements in unified performance scoring process. Which have the ability indicate the rule of element with indication of collaborative performance. So it will make it easier for the practitioners to score and to troubleshoot the performance. In addition have the ability to forecast the performance aptitude.

2 III.

System Support Engineering (sse) Decisions such as asset replacement, upgrade or system overhaul are in many respects equivalent to a major investment, which is risk sensitive. Therefore, solution centered proposition is needed. This proposition is form of system support engineering (SSE) (Mo, 2009). Figure 1 maps-out the nature of system support engineering in the development process of an asset.

3 II.

4 In Hand Research Literature

Researches on methodologies of providing services with a manufactured products has started on the early eighties of the last century (Baines, Lightfoot,) SSE concept involves the integration of service and system engineering to design support solutions. It incorporates a core knowledge base, drawing upon principles derived from a wide range of business and engineering disciplines. SSE is "solution centered", delivering output solutions which are a mix of service and product. Service is a dynamic and complex activity. In all services, irrespective of industry sectors or types of customers, services are co-produced with and truly involving consumers. In support solutions, service engineering and system engineering are used together as critical knowledge agents to guide the solution design. Service engineering emphasizes customization of solution designs to meet service needs, while system engineering emphasizes technical performance of the solution. "Service and Support" is a strategic business model. The customer/supplier relationship is different from those of transactional service offerings where interactions are limited mainly to episodic experiences. In this model, the interactions with the customer are enduring, like the systems they support, and a support solution seeks to cement a constructive long term customer relationship. To simplify these process a generic architecture of SSE was drawn by employing a empirical research (ALSaidi & Mo, 2013).

SSE framework is consists of 3 elements (People, Process and Product) in an operation environment. Also, it contains three levels structure (Execution, Management and Enterprise). The SSE framework model called 3PE model as shown in figure 2. This model was verified through multiple industrial visits and professionals contribution during data collection process. The SSE framework was able to outline the relation between the elements of system support. However, the details interaction is still yet to be investigated further. The investigation aims to explore the nature of these interactions and how they get affected by the environment. Nevertheless, the environment concepts themselves need to be clearly defined. In order to do so, the performance concepts of the SSE need to be demarcated in understandable relationship which is the target of this paper. 3PE model is used to structure and calculate performance, as the whole idea of the support system engineering is to sustain the performance of the operating asset. The main challenge at the start is to select a methodology to build and present the structure performance calculation. Talking to a range of professionals in the field, nearly all of them recommended a hierarchy build up format. They did not know the details but they thought it is the best if it can be achieved and easier for them to use and understand. Moreover, the input could be straightforwardly distributed to multi management levels. In addition, literatures overview showed that the advantage of buildup methodology is reducing the amount of error or the error contribution to the final score in calculation. Therefore, the structure of performance calculation was drawn as hierarchy structure so it will be easier to follow and include additions.

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IV.) and evaluation structure. Therefore, the structure of performance calculation was proposed and drawn as hierarchy structure so it will be easier to follow and include additions. Moreover, it is more popular structure with most professional practitioners in the industries which were visited and reviewed by the authors. The challenge was to formulate an equation to accommodate the elements in a simple format, keeping in mind the interaction and interface between the elements evaluated in the 3PE. Moreover, this formula should be generalized to all support systems which is a huge difficulty by itself. After long surveying and reviewing performance measurement systems available in the literature, equation [1] was proposed to be tested and verified. The proposition is not finalized yet but it provides a good start point.

6 Performance Scoring Structure

7 P = ?X + ?Y + ?Z

(1)

There is a need to develop performance scoring and calculation generic structure. After an industry based investigation, it has been suggested a build-up methodology for performance calculation as shown in figure 3. ? w n is the contrition weight of that element or the KPI score. ? 1 = w1 + w2 + wn-1 +wn ? E is the environment where all this elements are performing. Environment will have an effect or an impact on the performance of these elements. The environment factor could be included in KPI score marking.

The generic detailed elements in order to calculate the factor "People (X)" is presented in the figure **??**.

Figure **??** : Performance scoring and calculation outlines for people ("X" factor)

Where "w n " is evaluated and distributed in each level separately from other levels but cumulative distribution weight for the calculated element or the interface effect between two elements, as 1 = w 1 + w 2 + w n-1 +w n

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The generic detailed elements in order to calculate the factor "Process (Y)" is presented in the figure **??**.

Where "w n " is evaluated and distributed in each level separately from other levels but cumulative distribution weight for the calculated element or the interface effect between two elements, as 1 = w1 + w 2 +

w n-1 +w n Same-wise, the generic detailed elements in order to calculate the factor "Product (Z)" is presented in the figure **??**. These structures of performance calculation gave the ability to estimate the risks could be associated with each element and the service provided to it. This risk could be identified based on the work environment analysis. Therefore, the first step in the risk identification is to define the work or operation environment and in some cases even the business environment. This analysis is guided by the risk analysis process in SSE model.

V.

9 Industrial Example

Receiving feedback information about the actual world, and using the fresh information, is essential to review our understanding of the current industrial practice. Learning process always required particular level and depth of understanding of the system. Literature shows that several steps should be taking in order to realize certain depth of understanding (Correa & Keating, 2003). Moreover, Literature shows that because of its unique strengths, case study research is often used for developing new theories. The external validity of multiple cases is not problematical issue or core requirement (Robert K. Yin, 2012) but it will strengthen the validation of the approach. The targeted benefits of industrial example are: ? An extension of the development technique of exiting engineering asset management in the industry by more explicitly treating their sustainability with the performance sustainability. ? Validation of the sufficiency of measurement tools for establishing roles and responsibilities for performance. ? Documentation of the realities of the world of professional practice regarding large and complex engineering systems. ? Determination of the validity of the assumption employed by current systems engineering and performance standards.

? Guidance based on established practices on how to consolidate the engineering asset functions responsible for supporting the performance. All in parallel of our expansion of understanding the roles and responsibilities of the performance charged with overseeing and ensuring the success of support system engineering and integration at the system level.

? Introduce recommendation of further studies and activities.

It has been indicated that the most commonly popular data collection methods are: interviews, questioner and observation (Stanton, Salmon, Walker, Baber, & Jenkins, 2012) depending on the case or the reason for data collection. There are fruitful examples published in the literature on combining more than one method to accomplish better results on data collection (Borrego, Douglas, & Amelink, 2009; Lan & Ramesh, 2008; Runeson & Höst, 2009; Robert K Yin, 2011). To sum up, collecting conscious-based data through selfreporting is not good enough to succeed high accuracy information. Therefore, an interpolation from people involved in the studied system to describe their professional understanding and thinking is included. The targeted information in regard to:

? Classification.

? Authorisation.

? Study, design and planning. Firstly, the critical feedback roots were highlighted and rated in order to capture and evaluate important results. Literature suggested that it could be useful if the research could order them based on the importance which could be difficult in these cases. Instead the number and size of inputs and outputs of each root was considered to be the importance indicator. The second strategy is to analyze outcomes of the complexity. Using cause map as a step toward system dynamic modeling (Woodside, 2010). Such Couse maps will highlights the responds communication roots of real-life complex practice in the studied systems. The data were collected from automotive parts manufacturer. There is variety of processes which manufactures wide range of parts build legitimately complex manufacturing system which need to be supported by reliable and effective asset management system.

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With keeping the focus on the engineering asset management, the industrial example: ? Provides Logical connections among the observed events, ? Relying on knowledge of how systems preforms.

? The relation of the Organizations and individuals work.

The Data gathering process was lengthy process due to the complexity of the system. Figure 7 shows layout of the data gathering and structuring process.

? Implementation planning, management and execution. system. Also, it needs to indicate the overall performance value and how much really each element is affecting this score. The data then will be used as a verification inputs in the established equatione.

In the case studied factory, manufacturing cells are performing together forming the operation and operations are performing together forming the production system to give final product which is delivered to a customer. Delivery is considered to be part of the production system in this case. Performance is valued based on established delivery categories. Data of manufacturing cells which are performing an operation is gathered and averaged out to give the system in formation of that operation. Then the total operations are gathered up to give the data information for the whole system.

Average System values of an operation are calculated by inserting the data into the following equations:? ?O n = [n)] / k ? ?O n = [n)] / k ? ?O n = [n)] / k

Average Whole system values are calculated by inserting the data into the following equations:? = [n)] / R ? ?M = [n)] / R ? ?M = [n)] / R

Where "k" is the number cells contributing to that operation

Where "R" is the number cells contributing to that to whole manufacturing system "M"

Literature says that usability of process models is powerfully associated with its simplicity of understanding (Mendling, Reijers, & van der Aalst, 2010). The framework provided three increasingly detailed views or levels of abstraction from three different perspectives. It allows professionals to look at the same system from different perspectives. This creates a holistic view of engineering asset management. The framework in this regards helped to: o Guide to set requirements identification procedure for the development process of an operational engineering asset management system in the factory.

o Provide an overview of the behavior vector of an engineering asset management system development process and clearly drawn relations between elements.

11 CONCLUSION

The paper presented an approach to evaluate the performance of an asset management system. This paper briefly discussed the attempt to induct a structure to evaluate the performance of an asset management system. Based on the SSE framework, this paper provides a detail approach to estimate the performance. The research suggested that this could be a useful tool or techniques that practitioners in the industry can apply to help them in service design for operating assets in order to maintain optimized performance. The difference in developing this technique is that it has been inducted from the industry and Allow for interpolation from professionals in the system to describe their practical understanding and thinking. Therefore, it becomes easier to be implemented or used by the practitioners and this could be the main advantage from the preceding research work in this area. The findings suggested that further investigation need to be carried out. The aim of this investigation is to detail the effect(s) of operation environment on the 3P elements in regard to their performance in asset management system. Never the less, the effects of the interface and/or interaction between the 3P elements should be taking into account in this investigation as well.

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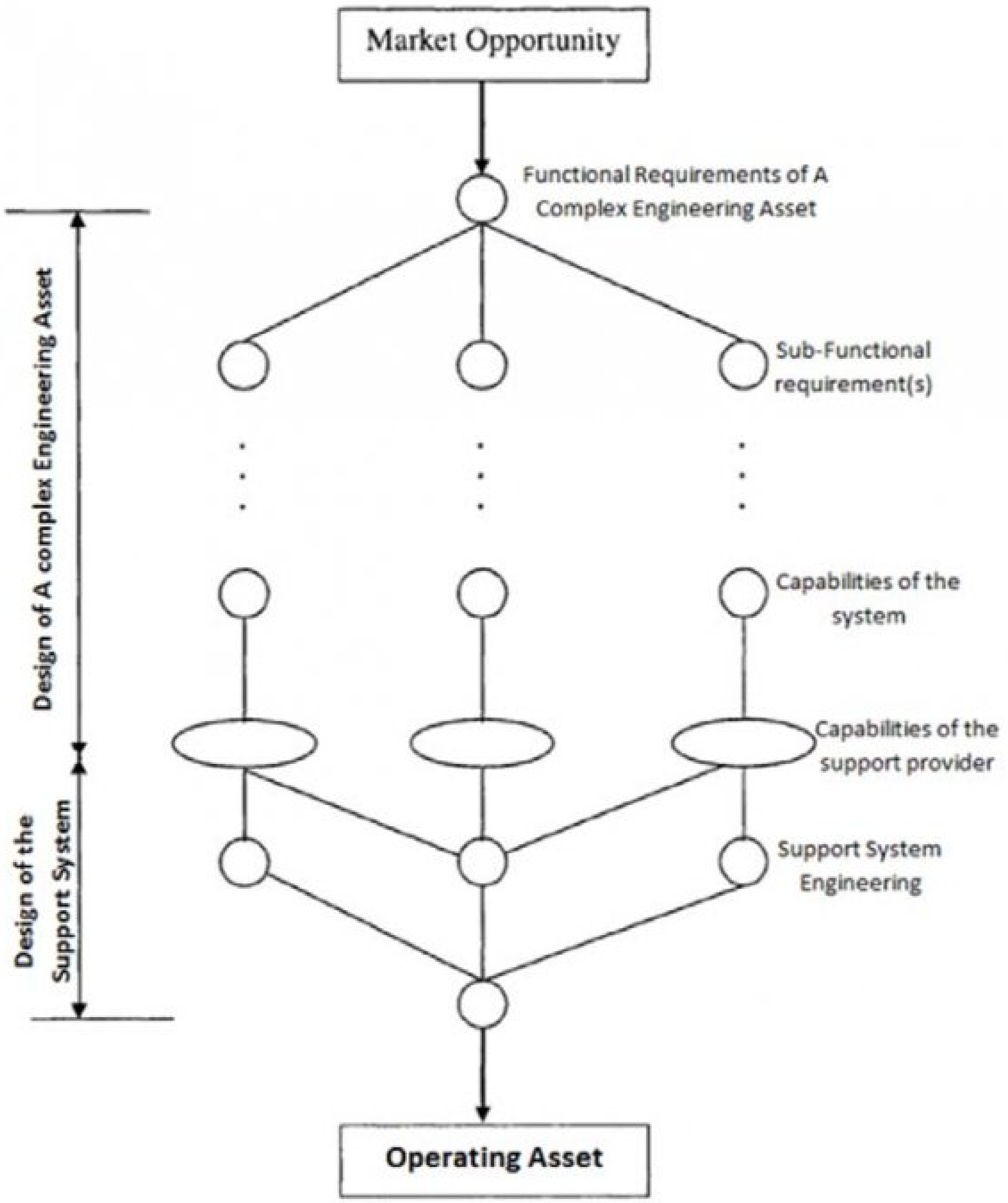
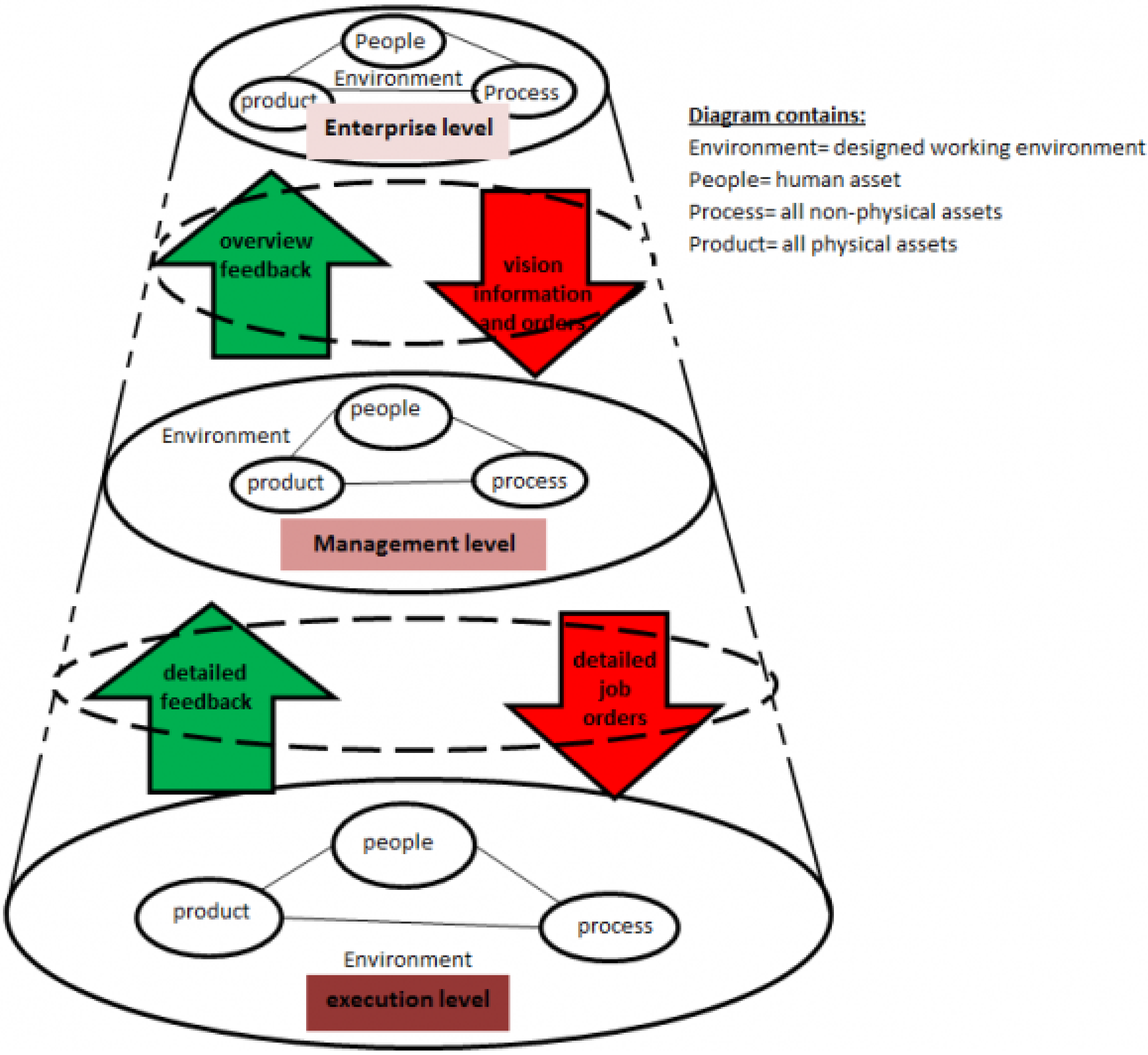
Figure 1:

[1] [2]



1

Figure 2: Figure 1 :



2

Figure 3: Figure 2 :

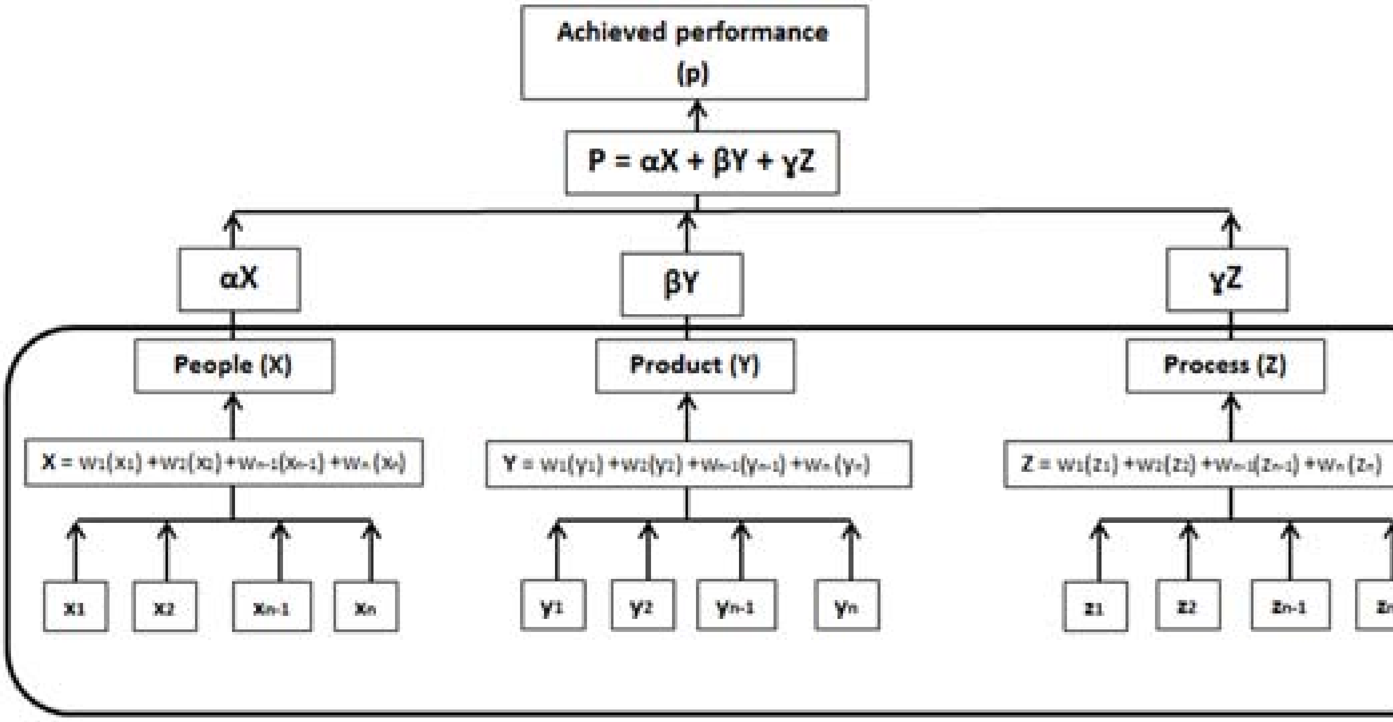


Figure 4:

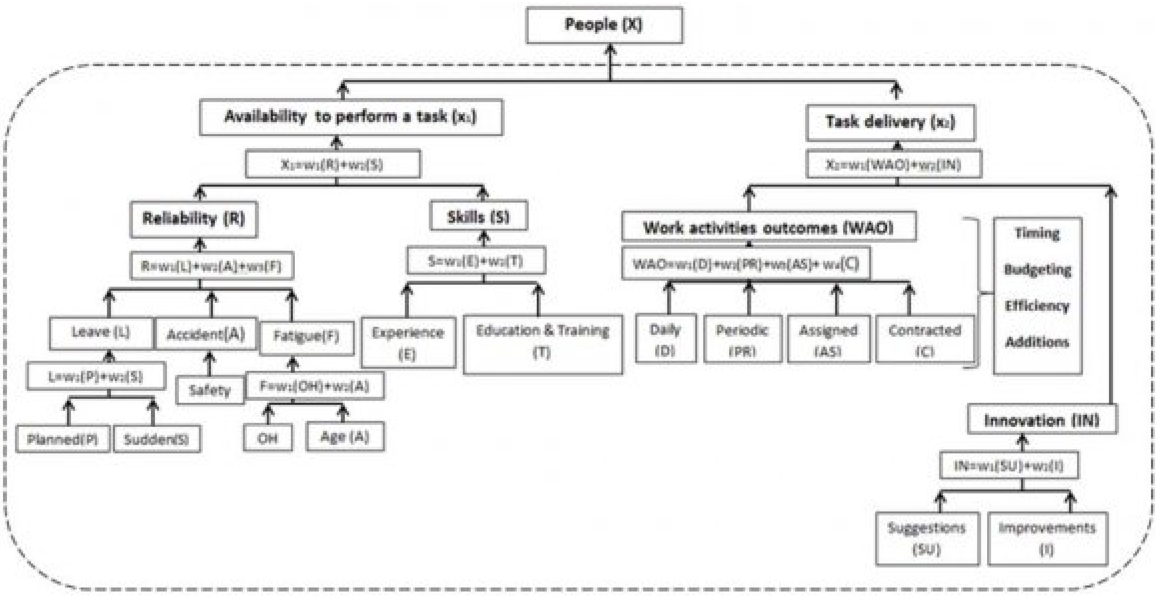


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Figure 5: Figure 3 :

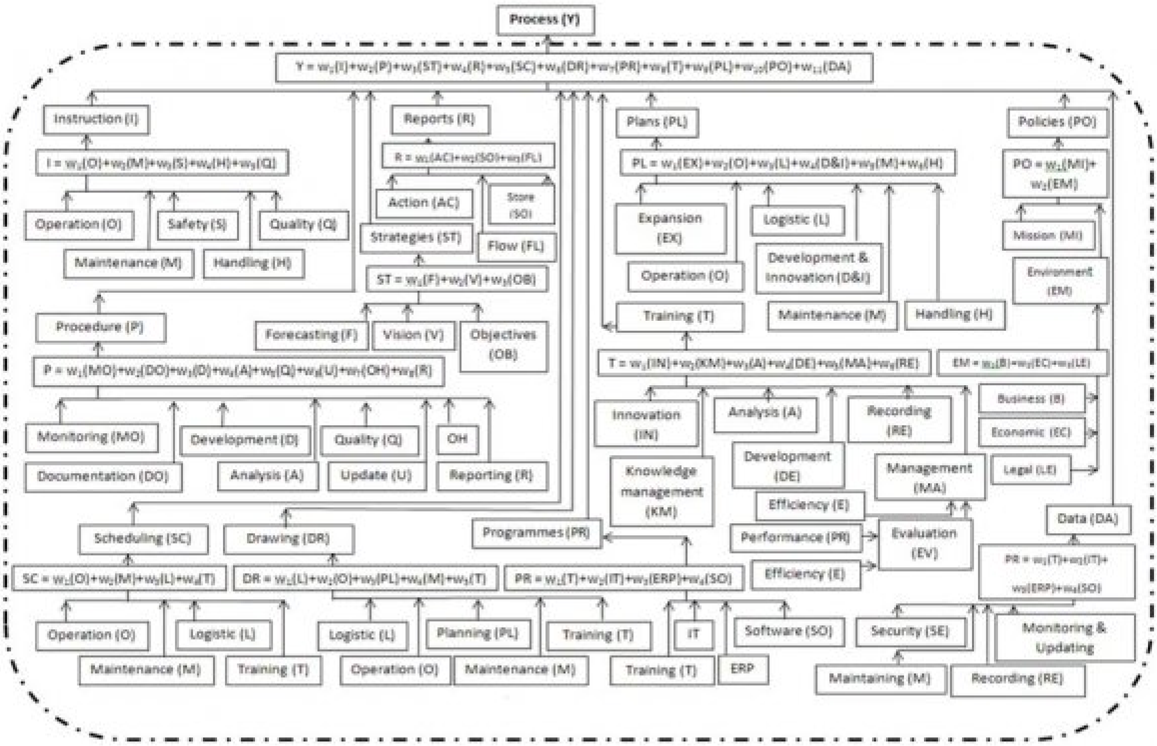

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Figure 6: Figure 5 :)Figure 6 :

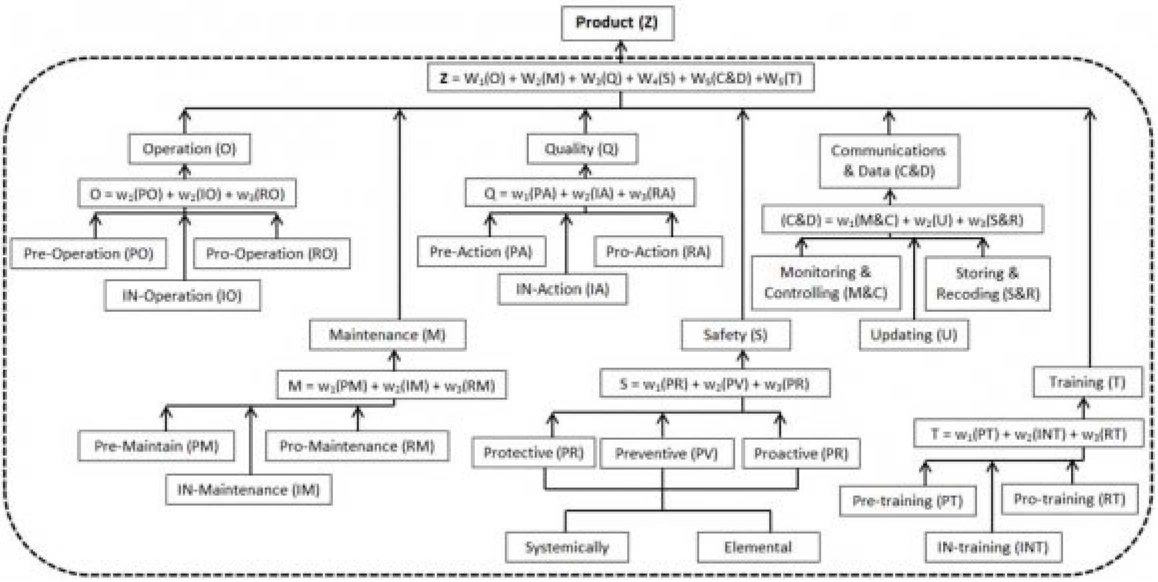

Figure 7: ?

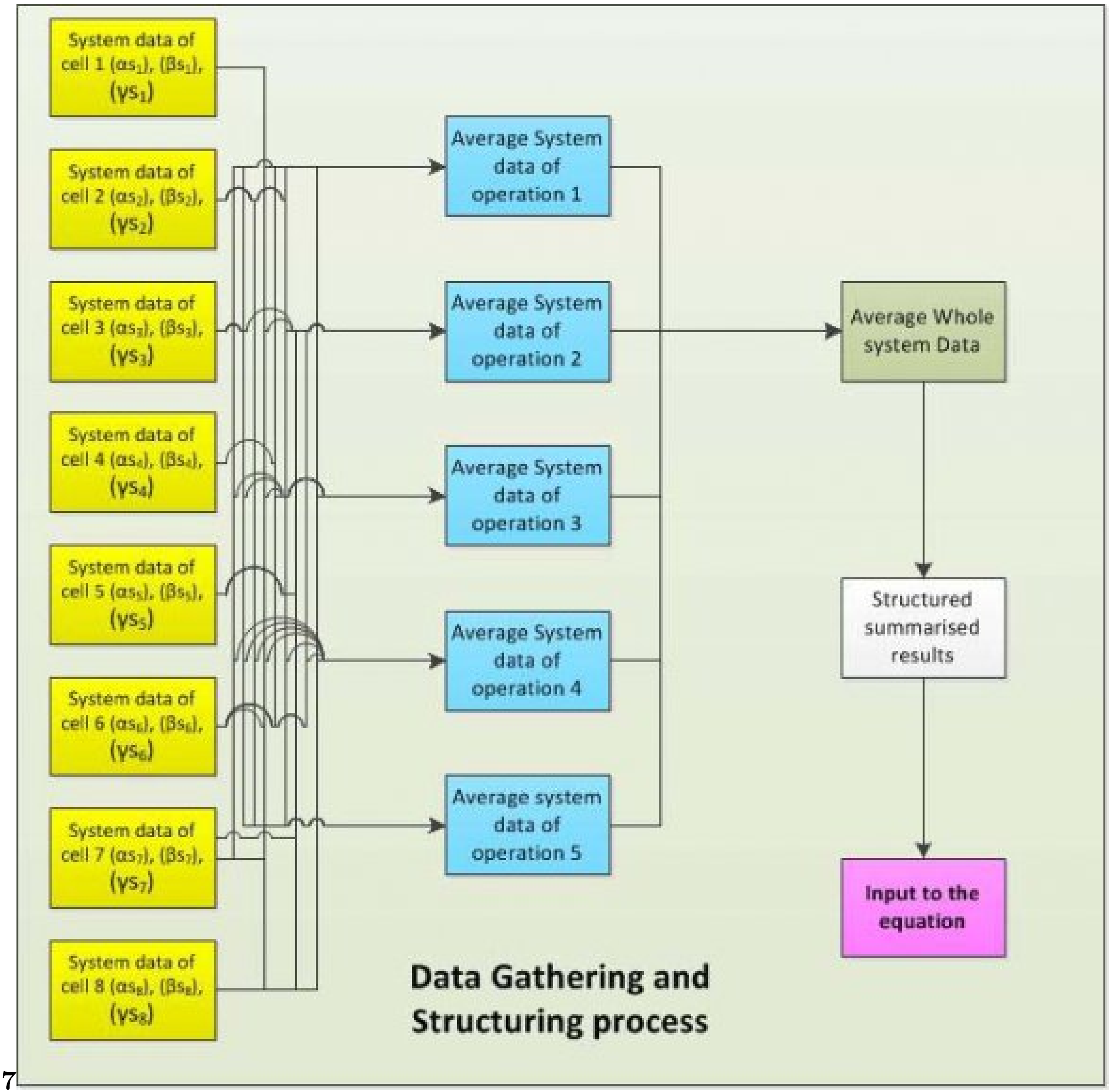

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Figure 8: Figure 7 :

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Figure 9: ooFigure 8 :

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Figure 10: Figure 9 :

Figure 11:

Figure 12:

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