THE IMPACT OF SHORT INTERVAL CONTROL & VISUAL MANAGEMENT CONCEPTS TO THE ORGANISATION'S OPERATIONAL PERFORMANCE

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ABSTRACT

The two concepts of Short Interval Control (SIC) and Visual Management (VM) have been used independently over the years by some of the successful companies in the world. The concept of Short Interval Control (SIC) is one of many structured processes that could arguably be utilised to achieve successful operations within any organisation. It is a process that involves intensive and interactive short stand-up meetings, coupled with a detailed list of actions, problems, status, and progress, all updated and captured in real time on whiteboards.

The VM concept has been used intensively as one of the lean techniques in the manufacturing and service environment as a process that addresses most of the important elements of lean manufacturing parameters such as processes, clarity, visualisation, vision, goals, understanding and control.

The objective of the study herein was to analyse and verify the impact that could be realised to the operational performance when these two concepts are implemented jointly and in synergy throughout the operational value chain associated with the delivery of spares items to the overseas clients, for the maintenance and survivability of the organisation's (BAE Systems OMC) fleet of vehicles which are in excess of 2 000 in the field.

Both the quantitative and qualitative research methods were used in a case study to comprehensively and rigorously attempt to answer applicable research questions and resolve the respective problem statements. Extensive theoretical and literature reviews were conducted to respectively analyse the theoretical perspectives of the two elements and to address findings related to the problem at hand from previous research efforts.

The findings revealed remarkable outcomes. From both literature and findings from the study it became evident that the two concepts are management systems/techniques which are mutually inclusive and can't be separated from each other when applied to the specific operational value stream like the one used in the case study herein. It was therefore concluded that the synergetic application of SIC and VM concepts have a positive impact and improve the organisation's operational performances.

Key words: Objectives, value chain, processes, visualisation, improvement, control, performance.

INTRODUCTION

Background

South Africa, like most of the African countries is still regarded as a developing country. It has both well established companies and a fair number of companies in their growing stages, of which their existence contributes to the country's comparative advantage. The theory of comparative advantage

states that “a country has a comparative advantage in products that make intensive use of resources available in abundance within that country” (Grant, 2010).

What this theory does not address though is how these resources should be utilised throughout the organisations’ operational value chains, to bring about the companies’ as well as the industries’ competitive advantages, and therefore the country’s comparative advantage. The above mentioned resources could arguably be effectively and efficiently utilised by implementing structured business techniques which identify opportunities and critical aspects of the business and therefore, action them immediately within a short period of time to achieve success operations.

Most successful structured business techniques are designed to address one of the critical and central leadership techniques of aligning resources (in a form of people and infrastructure), processes, activities and business objectives with the aim of enhancing the organisation’s operational performances and therefore company’s competitive advantage. This notion is also supported by Grant (2010) in his definition of the strategy. Grant (2010) defines strategy as “the match an organisation makes between its internal resources and skills and the opportunities and risks created by its external environment”. “Most South African manufacturing organisations are still far from being competitive in world-class terms” (Vermaak, 2008). Vermaak (2008) presented this notion during his research on the critical success factors in implementing lean thinking in South African organisations.

Many companies in South Africa have little or no indication of the costs involved in maintaining their supply chains, nor of the impact that these have on their operations (Datascope Consulting, 2008:84). It is therefore the author’s perception that even today few South African companies are actually utilising and taking advantage of successful management techniques to improve their operational performances. The concepts of Short Interval Control (SIC) and Visual Management (VM) are two of the management techniques that the author is to explore within the study herein to understand their phenomenon, contribution and impact to the organisation’s operational performance so that the outcome can be generalised, operationalized and translated into practical recommendations that could be used by South African organisations.

The study herein was carried out by analysing and verifying the impact of utilising the SIC and VM concepts throughout a specific business’ operational value stream within an organisation called BAE SYSTEMS Land Systems OMC (OMC) which has henceforth referred to as OMC. OMC is a South African company and a global player in the design, development and manufacture of mine and Improvised Explosive Device (IED) protected vehicles.

OMC covers all disciplines of the armoured vehicle spectrum including conceptualisation, design, development, manufacture, production, refurbishment, global in-service support and supply of spares items for maintenance and survivability of its products in the field. The case study within this organisation was carried out to analyse the impact of the two concepts; SIC and VM throughout the operational value chain associated with the preparation (where preparation includes; verification of the definition of spare parts, planning, procurement, manufacturing, inspection and material handling and packaging) and delivery of spares items to the overseas client for the maintenance and survivability of their fleet of vehicles which are in excess of 2 000 vehicles in the field.

Research Problem

OMC's performance in regard with the supply of spares items as mentioned above has been poor for an unacceptable period of time, much to the dismay of the client. Senior management made several attempts to address the problem by allocating more resources, authorising extra working hours, exerting pressure on suppliers to supply quality parts on time every time. None of these attempts were sustainable and therefore, were unable to improve the performance. The problems started to be clearly defined and understood once one of the senior managers was appointed as a fulltime programme manager to take over the proceedings to try and bring synergy to the process within the specific business value stream.

Realising the magnitude of the problem and level of effort required to address it, the organisation decided to seek help from the area of professional practice which manages the general process of change that is mostly laid claim to by professional change agents. The professional change agents were brought in to implement structured management techniques which are designed to identify opportunities and critical aspects of the business and therefore, action them immediately within a short period of time to achieve success and enhanced operational performance. The structured management techniques introduced were the concepts of SIC and VM.

Therefore the research questions this study intended to answer were to address the impact of the implementation of these introduced concepts of SIC and VM. The questions were constructed as follows:

i. What are the operational key performance indicators/variables that are used to assess, analyse and track operational processes/activities within the entire operational value chain during the preparation and delivery of the applicable spare parts so as to meet the customer's objectives?

ii. What impact does the use of Short Interval Control and Visual Management concepts have on these operational key performance indicators and the overall operational performance?

By answering the above questions, the objective of this study to determine and verify the impact of the SIC and VM concepts to the organisation's operational performance would be met. The applicable research hypothesis; H1 and sub-hypotheses; $H1_1$ to $H1_n$ (applicable to identified key performance indicators 1 to n) had also been developed as a results of discussions and analysis of inputs from the relevant literature study.

Figure 1 below illustrates the summary of the research problem and the rest of the objectives in a structured format.

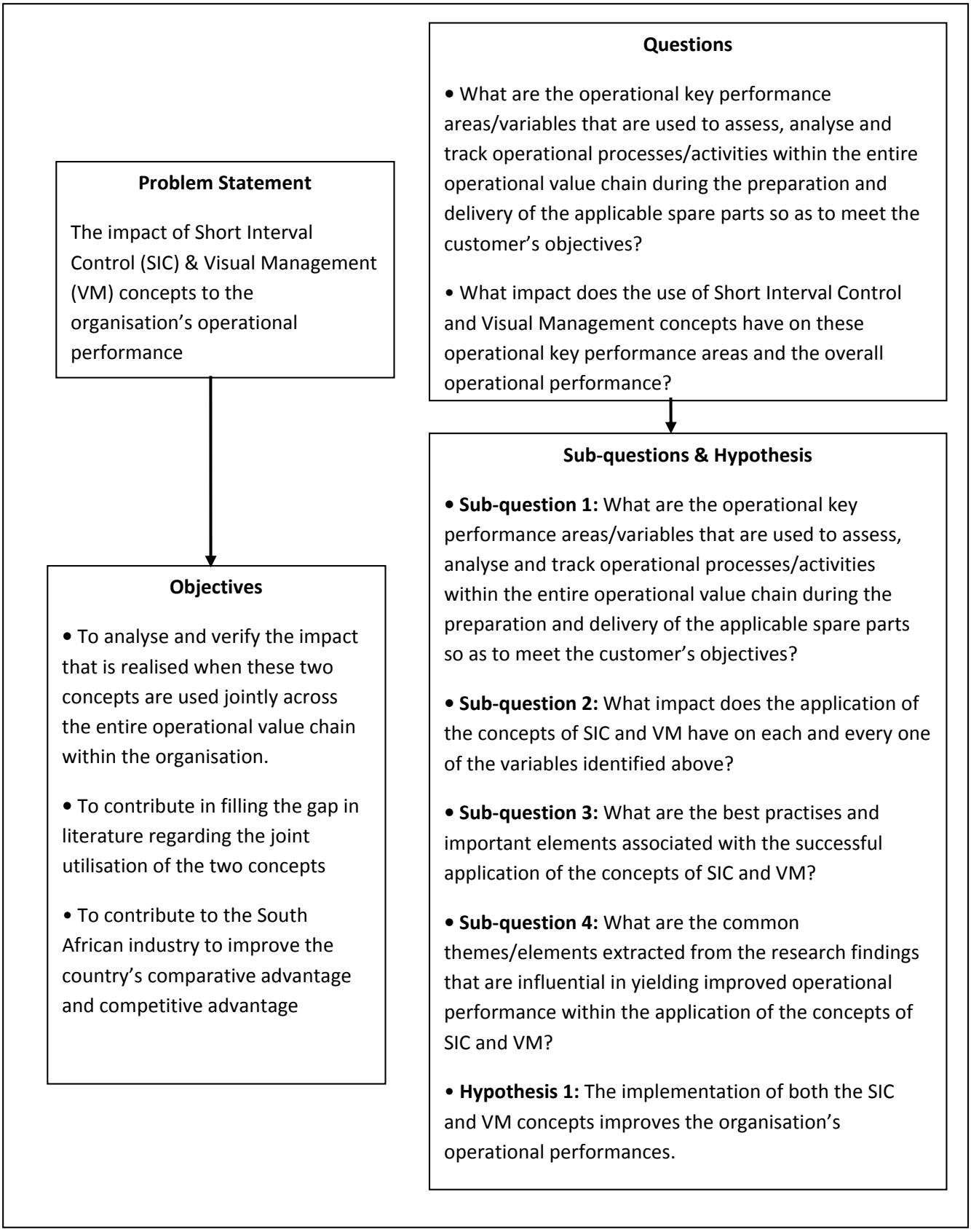

Figure 1: Research problem and objective summary, Source: Adapted from Strydom, I. 2009.

Importance and Benefits of the Study

The perceived benefits of this study are therefore summarised into categories as discussed below:

i. Benefits to the organisation under study. Outcomes of this study will provide the organisation with critical information in a form of an applicable process and performance gaps which can be exploited to further improve on the current successes and rectification of failures. This will provide the organisation with the competitive advantage in a form of innovative processes and solutions. Lesson learnt from the spares supply area will be applied in other operations of the organisation to benefit the entire organisation.

ii. Benefits to the manufacturing and other applicable industries which would be suitable to utilise the two techniques to improve their operations' efficiencies and effectiveness. OMC also plans to share the knowledge with its suppliers so as to have a concept of backward integration control in the supply chain to constantly deliver spare parts on time, every time.

iii. Benefits to South Africa as a country. South Africa will gain the comparative advantage as it will to a large extent be able to effectively and efficiently make intensive use of resources available in abundance within the country.

iv. South African government and the Small and Medium Enterprises (SMEs). The techniques herein can be introduced and entrenched into fairly new companies and SMEs to avoid business failures due to inefficiencies and ineffectiveness and, therefore further alleviate the problem of poverty.

v. Benefits to the Operations Management Body of Knowledge (OMBOK).

vi. The results from the research will also be used to identify other gaps between the organisation's management activities and processes, and theoretical management activities and processes.

vii. Benefit to the applicable institutes, like the South African Institute for Industrial Engineering (SAIIE) by presenting the research findings at the institute's annual conferences.

Literature Research

This sub-section of the paper is intended to address findings related to the problem at hand from previous research efforts. The section will also address concepts which are similar to or in contrast to the problem concepts at hand; i.e. SIC and VM and their relation thereof to operational performance and processes.

Visual Management (VM) concept

Tezel, Koskela & Tzortzopoulos (2009:1) in their research on identifying VM functions and the theoretical base for the construction industry, they cited Liff and Posey's (2004) VM definition as follows; "VM is a management system that attempts to improve organisational performance through connecting and aligning organisational vision, core values, goals and culture with other management systems, work processes, workplaces elements and stakeholders, by means of stimuli, which directly address one or more of the five human senses (sight, hearing, feeling, smell and taste)". This definition constitutes an important element of the organisational performance which

the author seeks to verify through the research herein. It addresses the link between the concept of VM and the impact it might have to the organisational performance.

Findings from the research conducted by Tezel *et al.* (2009) identified nine VM functions which serve a wide range of functions within an organisation. The nine identified functions are transparency, discipline, continuous improvement, job facilitation, on-the-job training, creating shared ownership, management by facts, simplification and unification. All of these functions are considered to be influential and relevant as they have direct impact to the organisation's operational performance.

Ad Esse Consulting Ltd. (2007:1) supports the definition above and built on it by further describing VM as follows; "Visual management is one of the lean manufacturing principles designed so that anyone entering a work place, even those who are unfamiliar with the detail of the processes, can very rapidly see what is going on, understand it and see what is under control and what isn't". This together with Liff and Posey's (2004) definition above are some of the comprehensive definitions of what visual management is, as they address most of the important elements of lean manufacturing parameters such as processes, clarity, visualisation, vision, goals, understanding and control.

The definitions above further emphasises the connection and alignment of the organisational goals with other management systems and operational processes within the organisation. From this definition, it is therefore suggested that the concept of VM can be referred to as a management technique that can be used to align and connect applicable elements from organisational objectives right through to the establishment of key performance indicators, and the influence they have on the organisational performance during the operations in the organisational value stream.

Short Interval Control (SIC)

Mascitelli (2007) in his research on lean product development explains and verifies a process methodology which yields improved organisational performance. He does this by identifying and addressing a management concept which he acknowledges as the best place to begin a lean product development transformation. He explains this management concept as a process that involves intensive ten minutes stand-up meetings. He emphasises that these meetings should be ten minutes of intensive interactions, coupled with a detailed list of actions, problems, status, and progress, all updated and captured in real time on whiteboards.

Vorne Industries Inc. (2010) also defines a similar process as a factory-floor process that engages team members to review performance data three or four times within their shift to assess where they need to focus their efforts to improve performance. They term this process a Short Interval Control (SIC) process. They further define it as a structured process for identifying and acting on opportunities to improve the effectiveness and efficiency of a production process. To achieve this goal, during each SIC review a series of the following steps must be completed:

<u>Looking Back to the Just-Completed Interval</u>

i. The Review of Previous Losses. This is used to evaluate the top losses for potential countermeasures.

ii. The Assessment of Previous Actions. This is to evaluate their effectiveness and whether follow-on actions are needed.

Looking Ahead to the Next Interval

i. The Identification of Risks. This is to identify upcoming conditions and changes that may adversely affect performance.

ii. Deciding on Actions. This is to decide on a specific set of actions to be completed during the next interval

The actions decided upon during the SIC review process are then carried out by the team members to maximize production during their shift. Figure 2 below clearly illustrates the process model and the required steps within the process.

Wilson (2004) described the SIC concept as "a management technique that could be used to effectively control a process with the aim of yielding improved performance". He further explained the concept as a process of collecting data related to the performance more often so as to easily create more opportunities to identify problems and to intervene to improve performance.

A principle which is closely related to the definitions provided above is that of Lean Manufacturing. Elbert (2012) defined Lean Manufacturing as "a methodology, based on the end-user customer's perspective, that is used to reduce and eliminate wasteful non-value added cost resulting in unnecessary steps in a manufacturing or business process which will, in turn, increase the velocity of the product through the system".

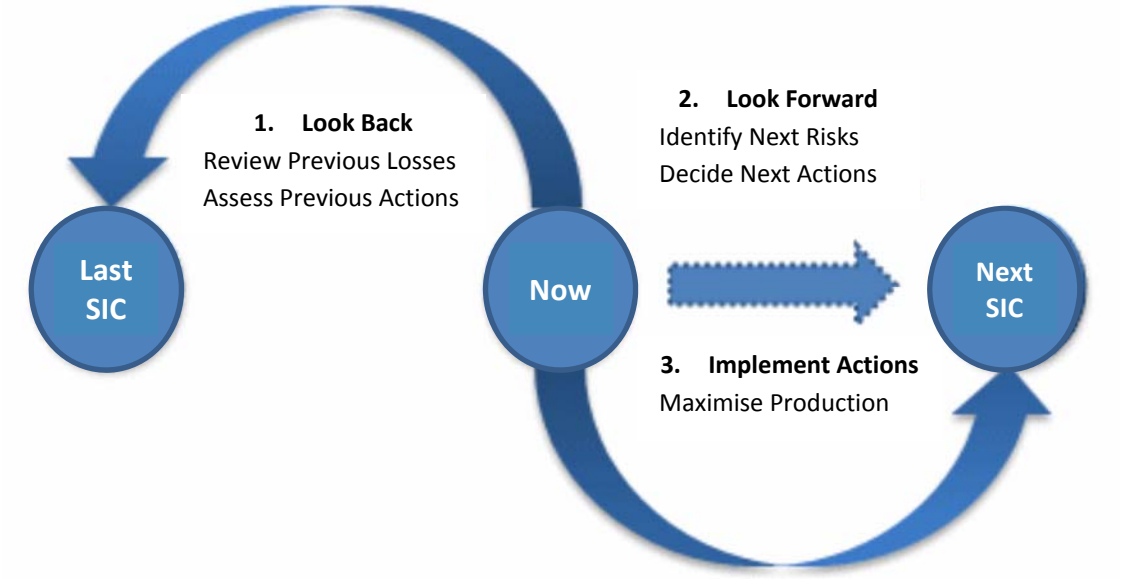

Figure 2: Typical steps in the SIC process model, Source: Vorne Industries Inc., 2010

The other most insightful definition of Lean Manufacturing is that of Narasimhan, Swink & Kim (2006) which defined lean manufacturing as being production that is accomplished with minimal waste due to unneeded operations, inefficient operations, or excessive buffering in operations. The author therefore suggests that the SIC concept is in actual fact a lean principle, hence focus on the discussions and analyses of what other researchers have already published in regards with lean principles and their impact to operational performance.

Detty and Yingling (2000) qualified the performance improvements that could be expected from applying the lean manufacturing shop-floor principles of continuous flow, just-in-time inventory management, quality at the source, and level production scheduling by using a simulation package named System Modelling Corporation's Arena software. Their simulation package also confirmed previous work by other researchers on lean principles and benefits.

Detty and Yingling (2000) also used the simulation package as an aid in analysing, designing and improving special elements of lean manufacturing systems within an organisation they used as a case study. The software simulation package can therefore be seen as an important tool which could be used to demonstrate the benefits and principles of lean without physically affecting the production processes, layouts, schedule and cost much to the delight of sceptical and bureaucratic operations managers.

One other important factor observed from Detty and Yingling (2000) was that the simulated performance improvements represented the consolidated benefits of all of the changes incorporated in the lean system and therefore promoted the systems thinking approach. The systems thinking approach focuses on interrelationships within the entire organisation rather than just concentrating on isolated events within the operational value stream. This approach of systems thinking introduces synergistic processes which focuses on long term solutions rather than short term solutions that might come tomorrow's problems. The negative impact of not using systems thinking approach when introducing lean principles, was observed by Brewer and Kennedy (2005) during their case study on the Lebanon Gasket Company (LGC).

LGC had hired Tom Walsh an experienced plant manager with an objective to turn around a plant that had been suffering from declining profits and margins, excessive waste and inventory levels, unsatisfactory on-time customer delivery performance, and shrinking market share. After 18 months on the job Walsh had managed to meet his objectives but nevertheless the financial results were disappointing. It was later observed that LGC's financial manager was not interested in lean principles and was still using old non-lean traditional accounting practices which were since adopted in 1979. These accounting methods were not serving their newly established value streams and Walsh made a mistake of believing that if he properly managed the manufacturing floor, the financial results would take care of themselves, but he soon learnt that, that was not the case. He eventually hired a Lean Enterprise Development firm to help LGC deal with their identified financial shortcomings.

The importance of continuous improvement practice and synergy are also supported by Canel, Rosen and Anderson (2000) in their journal which addresses the just-in-time principles. The discussions above have highlighted the significant importance of business process improvement techniques and therefore the SIC concept. The business process improvement techniques like the SIC concept are also regarded as being more significant than improvements on manufacturing processes and this notion is also supported by Kruger (2008) who addressed the improvement of business processes rather than the manufacturing processes.

Vermaak (2011) verified another shop floor principle of identifying and communicating real time shop floor information as having positive impact to decision making processes and hence improved performance. Vermaak (2011) further indicated that this principle could also improve performance by having real time performance indicators that are used to set the operational pace and common

goals. What Vermaak (2011) and the rest of the above quoted researchers hasn't addressed in their studies though, is the process of how the real time shop floor information was to be communicated or made visible and available to relevant individuals. The VM concept discussed in the previous sub-section herewith presents a suitable vehicle to address and communicate this information by means of visualisation on shop floor boards, hence the notion that the two concepts should be mutually inclusive and not be separated from each other when applied specific operational value streams.

METHODOLOGY

The author used two types of methodologies to control the study of the research; i.e. Quantitative and Qualitative methodologies.

Quantitative Methodology

As per the outcome of the problem statement, the author developed the hypothesis which was aimed to be verified and analysed through a quantitative process. Refer to Figure 1 above. The developed hypothesis was populated into a number of sub-hypotheses which were based on the operational key performance areas/variables which were identified using the data collected by the method of participant-observation.

The quantitative approach was selected to analyse the correlation between the implementation of the SIC & VM concepts and the identified operational key performance dependent variables. This approach was utilised to reveal the impact that the implementation of the SIC and VM concepts have to the operational KPI variables and therefore to the overall operational performances.

When two or more variables are correlated, researchers sometimes tend to conclude that one of the variables must in some way influence the other (Leedy & Ormrod, 2010). This phenomenon is referred to by (Leedy & Ormrod, 2010) as the faulty logic. The author therefore took cognisance of this faulty logic phenomenon and therefore decided to also conduct qualitative methods to yield more comprehensive conclusions about the cause-and-effect relationships between the applicable variables.

Qualitative Methodology

This method was chosen to complement, verify and validate the outcomes of the above mentioned quantitative process. The principles of the method allowed the researcher to formulate and structure applicable sub-questions (to support the main questions) which were used to test the validity of generalisations, remarks and claims that were collected during data collection. The well-structured questions provided means by which the researcher objectively judged the effectiveness and impact of the techniques which were under study.

Qualitative Research Design

The elements of the study herein were assessed in real-life within the organisational operations and management systems. This type of a research method is described by Yin (2009) as a case study method as he viewed the goal of case studies as understanding complex social phenomena, and real–life events such as organisational and managerial processes.

For the purpose of making sure that the case study herein was well constructed to ensure construct, internal and external validity, and reliability the author chose to utilise the elements of Yin's (2009) revised approach to theory-building with cases approach which consist of the following steps: (1) within-case analysis, (2) cross-case pattern search, and (3) testing.

i. Step 1: Within-Case Analysis. The within-case analysis entailed study and data collection within the main case herein, which is that of spare parts supply value chain within the organisation under study.

ii. Step 2: Cross-Case Pattern Search. During this step, two other cases (which were based on two other different value chains which have started utilising the concepts of SIC and VM) were analysed to identify the similarities and differences between the cases and as compared to the main case. These comparisons and outcomes served as convergent evidence for internal validity of the study.

iii. Step 3: Testing. The outcome of steps 1 and 2 were then used to verify the external validity as well as generalisation by evaluating information from one external company which has already implemented and are utilising the SIC and VM concepts.

Method of Data Collection

The method of data collection included the following:

i. *Participant-Observations* – The researcher observed the daily operations conducted within the entire operational value stream which was aimed to achieve the objectives of satisfying the customer by supplying the applicable spares items within the specified requirements. The following elements were observed:

    a. Operational performances before the utilisation of the concepts of SIC and VM. Refer to results on Figure 3.

    b. Operational performances during the beginning stages of the application of the concepts of SIC and VM. Refer to results on Figure 3.

    c. Operational performances during the application of streamlined and verified concepts of SIC and VM. Refer to results on Figure 3.

    d. The improvement process tools utilised in developing key performance indicators and supporting the establishment and implementation of the concepts of SIC and VM. Refer to Figure 4 for the results of a value stream mapping.

    e. Development and identification of the comprehensive operational key performance indicators. Refer to a sub-section named; Results B for the details of the developed KPIs.

    f. Performances of the established Operational key performance indicators.

    g. The level of commitment, responsibilities, degree of cooperation from of all stakeholders within the entire value chain and the impact of these activities to performance.

ii. *Questionnaires and follow-up Interviews* - In this study, questionnaires were used and also supported by follow-up semi-structured interviews. Leedy and Omrord (2005) argue that interviews can yield a great deal of useful and in-depth information rather than only completing questionnaires.

The questions within the questionnaire were based on the populated number of sub-questions and hypothesis which are stipulated in Figure 1. The hypothesis was further sub divided into sub-hypotheses as follows:

a. Hypothesis 1: The implementation of both the SIC and VM concepts improves the organisation's operational performances.

b. Sub-Hypotheses $H1_1$ to $H1_n$: The implementation of both the SIC and VM concepts improves the organisation's operational key performance indicators 1 to n.

The operational key performance areas/variables which were identified when answering the sub-question 1 above were used to formulate the dependent variables which were assumed to be directly involved in the correlation relationships with the dependent variables investigated. The concepts of SIC and VM were hereby considered as independent variables of which their impact to the dependent variables were investigated.

iii. *Reports Records & Documents* – daily performance reports were accessible to the researcher to capture and analyse. These reports included results on daily performances of various key performance variables, namely; Stock In Plant (SIP), Freeze In Date (FID), Due In Date (DID) and Backlog.

iv. *Focus Group* – a focus group was utilised to rigorously establish more common themes related to the success factors of the implementation of the two concepts. The focus group method also examined how the identified themes relate to the key performance variables. The focus group was also utilised to verify/validate the findings emanating from the rest of the data collection methods already mentioned. Refer to Appendix B of Attachment 1 for the questions discussed during the focus group session.

The details of the other questionnaires that were used are included in Appendix A of Attachment 1. These questionnaires were streamlined and populated with other relevant details during the observation phase of the research to relevant participants.

Unit of Analysis

The unit of analysis is the entity which includes who or whom is being analysed. In this case the unit of analysis was based on a specific company (BAE Systems OMC) and its stakeholders. Analysis on one other applicable company was also conducted to test the validation and generalisation of the outcomes. The sample within the unit was limited to the following participants:

i. Stakeholders within the entire operations value chain.

ii. Personnel from the development engineering department.

iii. Personnel from the industrial engineering department.

iv. Personnel in the supply chain department.

v. Personnel in the stores and material handling department.

vi. Personnel in the quality inspection department.

vii. Personnel in the production department.

viii. Personnel in the spares sales department.

ix. Operational control experts – Professional Change Agents.

Method of Data Analysis

The method of data analysis included the following:

i. The SPSS software was used to categorise, simplify, calculate and analyse the data and translated it into useful information; i.e. frequency tables and correlations so that results could be used to prepare conclusions.

ii. Categorisation of data in terms of common themes from responses to questionnaires and reports.

iii. Transcription and interpretation of data in terms of common themes from the focus group to extract relevant and applicable information.

iv. Synthesis of relevant and applicable information to formulate findings and conclusions.

Validity and Reliability of the Study

The preparation of questionnaires and arrangements of interviews done well in advance increased the probability of receiving reliable and valid data from the participants as they were given enough time to prepare and have the correct data ready before the questionnaires and interviews. Lack of preparation usually poses a risk of receiving bias, invalid and unreliable data. These inferior data was also identified by Saunders, Lewis & Thornhill (2007) as issues that plague semi structured interviews.

Utilising Document analysis methods of gathering data was another way of addressing the validity and reliability of data as these documents were existing documents which were accessible and readily available. Data sources were also validated for consistency by examining them at different points in time, along with the settings they evolved from.

All of the above mentioned processes of validating the data so as to have reliability were easily implemented by the researcher as he was part of the daily operations within the organisation under study.

FINDINGS

Results A: Performance history of the company

The findings discussed in this sub-section address the relation between organisational performance and the implementation of the concepts of SIC and VM so as to justify the acceptance or rejection of the **Hypothesis 1**; *"implementation of both the Short Interval Control and Visual Management concepts improve the organisation's operational performances".* During the capturing of data using

the following methods; Participant-observation, Reports, Records and Documentation, the following elements were observed:

i. Operational performances before the utilisation of the concepts of SIC and VM. Refer to the green line graph on Figure 3 for the average Due In Date (DID) performance for year 2011. The 2011 performance results shown does not only show previous poor performance but also illustrate the instability of processes within the operational value stream. If processes are unstable, then an intended improvement just becomes a further variation in the processes within the value stream.

ii. Operational performances during the beginning stages of the application of the concepts of SIC and VM which took place during the year 2012. Refer to the blue line graph on Figure 3 for the average DID performance for year 2012. The incremental improvements which emanated from the application of SIC and VM led to more stable and improved performance, and stability in processes within the operational value stream.

iii. Operational performances during the application of streamlined and verified concepts of SIC and VM which took place during the year 2013. Refer to the red line graph on Figure 3 for the average DID performance for year 2013. Results on this line graph demonstrate a much more stable and improved performance as compared to both 2011 and 2012 results.

The details of the results for the daily Due In Date (DID) performances throughout 2011 to 2013 are captured in Appendix H of the Attachment 1.

Results B: The development of Key Performance Variables

The findings discussed in this section address the process used in developing and identifying applicable and comprehensive operational key performance indicators (KPIs). These KPIs are the answers to the **sub-question 1**; "what are the operational key performance areas/variables that are used to assess, analyse and track operational processes/activities within the entire operational value chain during the preparation and delivery of the applicable spare parts so as to meet the customer's objectives"?

The effective introduction and implementation of the SIC and VM concepts constituted an establishment of a number of management processes which complements the success of the entire operation of the two concepts. The first improvement process that was introduced was the implementation of a value stream mapping process tool. This was done in two phases as per recommendations from literature review (Elbert, 2012; and Liker & Meier, 2005). Phase 1; a simple current state value stream was mapped, to identify all the departments, activities, activity process, lead times (in days), and flow processes that were at that point in time applicable within the value chain of preparing and delivering the spare parts items.

The outcome of analysing the current state and selecting the improvement activities led to the development and confirmation of key performance indicators (KPIs) as well as inputs to the future state value stream. Phase 2; a future state value stream was initiated (refer to Appendix G of Attachment 1 for the details of the value stream) by further identifying all improvement activities required to remove non value adding waste so as to meet the customer's requirements.

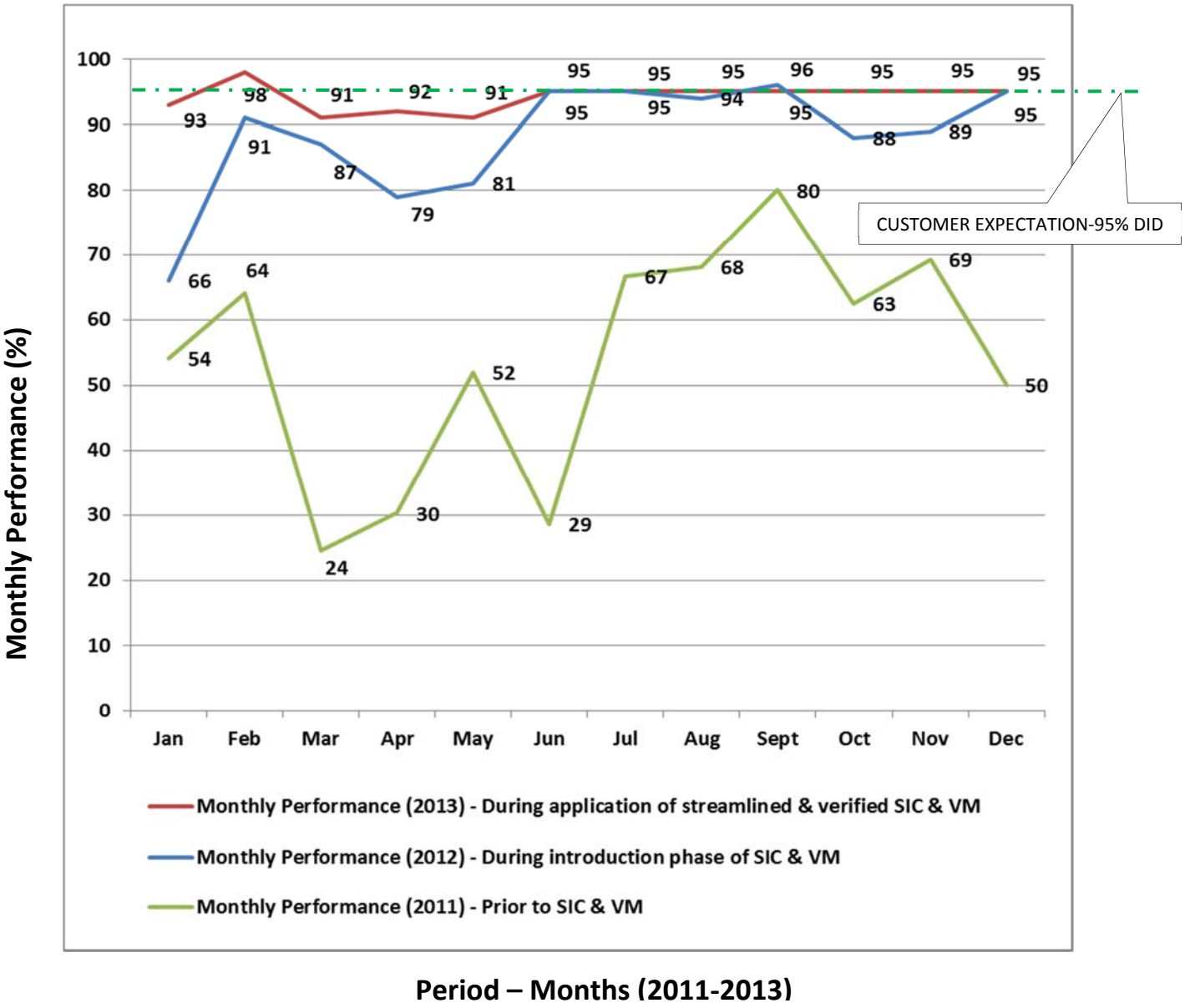

Figure 3: Monthly average DID Performance (2011-2013), Source: OMC

The established Key Performance Indicators; 1 to 11 which are supported by the activities from the value stream are listed and explained below as follows:

i. *Permits:* Timeous approval of permits to allow military controlled parts to be packaged for shipment.

ii. *Spare parts drawings:* Timeous release and availability of drawings for procurement and inspection purposes.

iii. *Stock In Plant (SIP):* Required delivery date of parts from the suppliers and internal works orders.

iv. *Scrap rate:* Reduced or eliminated scrap rate from the suppliers and internal assembly work.

v. *Stock levels:* Accuracy of stock levels in the ware house.

vi. *Flow of material:* Effective flow of material from goods receiving to stores and then to the dispatch area within specified lead times.

vii. *Identifying parts of high priority:* Capabilities of easily identifying items on a high priority list to enable timeous processing and delivery.

viii. *Internal works orders:* Effectively processing internal works orders for the internal assembly processes and timeous delivery of finished products

ix. *Freeze In Date (FID):* Required date to consolidate all applicable lines for a specific delivery date.

x. *Due In Date (DID):* The % delivery performance (on line items) on the final customer required delivery date.

xi. *Backlog:* Number of parts which missed their specific delivery dates.

The above mentioned KPIs play a critical role in supporting the ultimate customer requirements and therefore the overall operational performance.

Results C: Responses to questionnaires and analysis from a focus group

This sub-section presents results from the views of respondents regarding the impact that the concepts of SIC and VM have on the organisation's operational performances. The findings from questionnaires and a focus group, (i) provided verification to the acceptance of **Sub-hypotheses 1 to 11:** and (ii) provided answers to **sub-questions 2, 3 and 4.** A statistical analysis program; SPSS was used to validate the reliability of the data and measuring instruments, and for statistical analysis utilising the Cronbach's alpha ($\alpha \geq 0.70$) analysis (Laerd Statistics, 2013a), and Spearman's correlation coefficient ($p < .05$; and significantly strong) (Laerd Statistics, 2013b) to explicitly accept or reject the developed sub-hypotheses and their respective null sub-hypotheses.

Table 1 below presents the results of the Cronbach's coefficient analysis from the data collected from questions applicable to the application of the two concepts of SIC and VM. These questions are denoted by Q (for question) and the applicable number (1.1, 1.2 etc.) which are from Part 2 of Questionnaire 1 (Refer to Appendix A of Attachment 1).

Table 1: Cronbach (α) values indicating level of reliability

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q1.3	42.6875	35.829	.856	.968
Q1.6	42.6250	39.450	.738	.971
Q1.9	42.3125	36.896	.921	.966
Q1.12	43.0000	35.600	.880	.967
Q1.15	43.1250	32.383	.935	.968
Q1.18	42.1250	38.917	.828	.969
Q1.21	42.1875	37.096	.893	.967
Q1.24	42.3125	36.896	.921	.966
Q1.27	42.3750	35.850	.926	.965
Q1.30	42.1250	38.917	.828	.969

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q1.33	42.6250	36.383	.857	.968

The coefficient values of α greater than 0.7 are an indication of the reliability of both the collected data and the method used in collecting that data.

On the other hand the results of the correlations between the SIC & VM concepts and each and every one of the individual KPIs (identified in the previous sub-section) as per the Spearman's (ρ) Correlation analysis are presented in Table 2 below and discussions below as follows:

From the table below it is evident that the Spearman's (ρ) Correlation values for all variables (KPIs) are not zero and are in fact positive and significantly strong/high (Laerd Statistics, 2013c). This therefore concludes that there are positive correlations between the SIC & VM concepts and each and every one of the individual KPIs. The results in Table 2 also support the acceptance of the alternative sub-hypotheses; $H1_1$ to $H1_{11}$ and reject the null sub-hypotheses; $H0_1$ to $H0_{11}$.

Results D: Operational Performances from the External Validation

Figure 4 below illustrates findings from an external company, which demonstrate the relationship between operational performance and the application of the concepts of SIC and VM. The following analysis can be deduced from the illustration:

i. During year zero, where SIC and VM were not utilised there was abnormality or high fluctuation within the organisation's operational performance.

ii. During the early years (e.g. year 1) of the implementation of the SIC and VM concepts, the graph shows stability in regards with the organisation's operational performance

iii. As time went on and the implementation of the two concepts were streamlined, the operational performance was not only stable but it was improved as well

The above mentioned statements and the graph below serve as convergent evidence for external validity to support the results extracted from the case at hand.

Table 2: Spearman's (ρ) Correlation Coefficient Results

Variables	Spearman's (ρ) Correlation Coefficient	Sig. (2-tailed)	N
SIC & VM	1.000	.	16
Permits	.898**	.000	16
Drawings	.945**	.000	16
SIP	.940**	.000	16
Scrap Rate	.891**	.000	16
Stock Levels	.841**	.000	16
Flow of Material	.946**	.000	16

Variables	Spearman's (ρ) Correlation Coefficient	Sig. (2-tailed)	N
Identification of Priority	.945**	.000	16
Works orders	.940**	.000	16
FID	.938**	.000	16
DID	.946**	.000	16
Backlog	.937**	.000	16
**. Correlation is significant at the 0.01 level (2-tailed).			

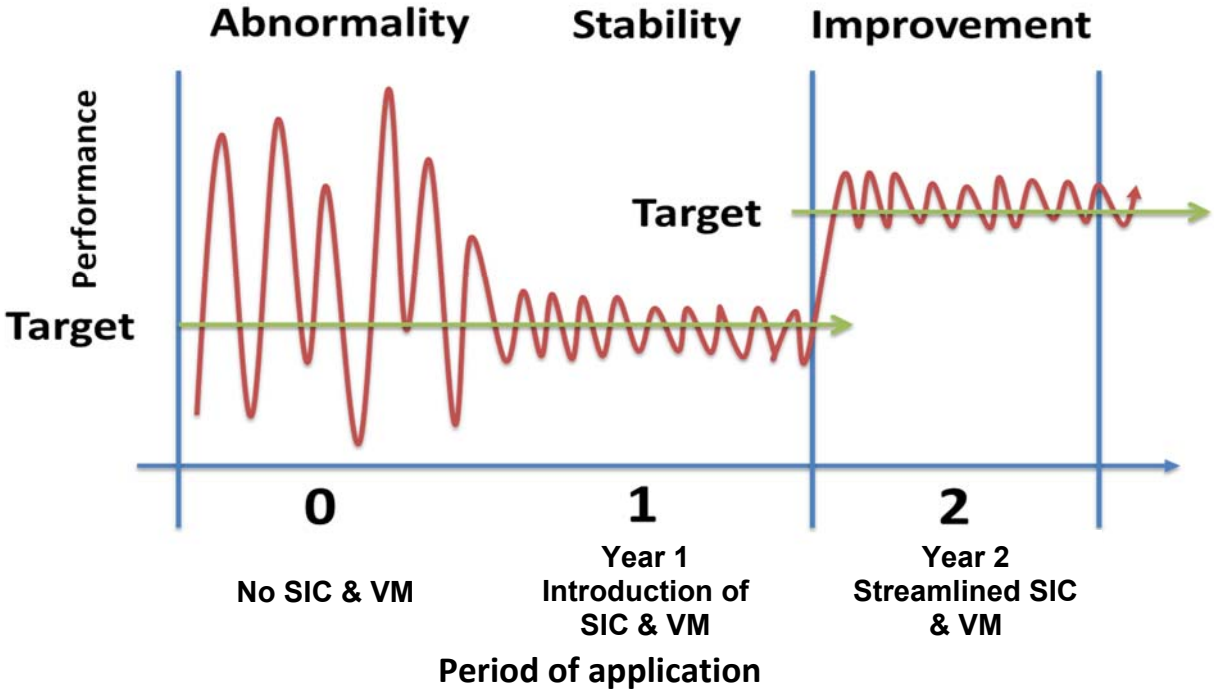

Figure 4: Operational Performance vs Application period of SIC & VM concepts (External Validation)

CONCLUSION

Conclusions: Hypothesis 1 and the sub-hypotheses 1 to 11

This section provides conclusions drawn from the findings from the previous section above. The findings above indicated that there is a linear relation between the two variables; i.e., implementation of the SIC and VM and the operational performances as shown by the performance improvements in Figures 3. This analysis therefore accepts the **Hypothesis 1; H1** which states; "implementation of both the SIC and VM concepts improve the organisation's operational performances", and rejects the **Null hypothesis, H0** which state; "implementation of both the SIC and VM concepts does not improve the organisation's operational performances".

The statistical analysis results from the SPSS program supported the acceptance of the developed sub-hypotheses and rejected the corresponding null sub-hypotheses. Below is one example of the final and proved sub-hypotheses. The rest are based on all identified KPIs 2 to 11:

i. Accepted sub-hypothesis 1; $H1_1$: The implementation of both the SIC and VM concepts improves the timeous approval and issuing of permits.

ii. Rejected null sub-hypothesis 1; $H0_1$: The implementation of both the SIC and VM concepts does not improve the timeous approval and issuing of permits.

Conclusions: Sub-question 1 to Sub-question 4.

Sub-question 1: The eleven operational key performance areas/variables that are used to assess, analyse and track operational processes/activities within the entire operational value chain during the preparation and delivery of the applicable spares parts were identified and thoroughly described in the findings section above.

Sub-question 2: From the findings discussed above it can be concluded that the synergetic application of SIC and VM have a positive impact and correlation to the identified key performance indicators. These results and discussions clearly provided a successful answer to sub-question 2.

Sub-question 3: The best practises and important elements associated with the successful application of the concepts of SIC and VM are summarised as statements in Appendix C of Attachment 1. It is also noted that some statements were identified as more applicable than others. Results and discussions emanating from the focus group session provided verification and validity to some of the initially identified practises. The focus session also presented additional practices which were not articulated via the collection method of a questionnaire.

Sub-question 4: All identified common themes/elements are presented in Appendix D of Attachment 1. The acknowledgement of these elements is also presented in a form of propositions that concludes that “the elements are necessary elements which have a high influential impact on operational performances within the application of the concepts of SIC and VM”. These propositions were externally verified as valid and influential.

From both literature and findings from the study it is evident that the two concepts are management systems/techniques which are mutually inclusive and can’t be separated from each other when applied to the operational value stream like the one used in the case study herein.

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