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Capability Assessment of Army Spare Parts Replenishment System: Suitability for a Dynamic Time Separated Lean-Agile Supply

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Purpose

The paper is aimed at identifying the strengths and weaknesses of the current spare parts replenishment system of the Army. This exercise is being done with an aim to assess the capability of the current system to implement a time separated lean-agile system of spare parts replenishment.

Design/Methodology/Approach

The paper is based on a survey conducted on people in managerial ranks, working in the field of military logistics. The survey is thereafter summarized to ascertain the current status of spare parts replenishment system in the army. The findings of the survey are elaborated at the end of the paper.

Findings

The strengths of the current spare parts replenishment system are highlighted. This is followed with the weaknesses of the system in implementing a dynamic lean-agile replenishment system.

Originality/Value

The paper is aimed at assessing the capability of the current spare parts replenishment system and its ability to adapt to a novel replenishment system that is lean in peace time to save money and agile during war to increase reliability of equipment achieved by a certainty of supply. The survey conducted on the persons actually involved in this logistics reveals areas that need emphasis in order to achieve such a time separated lean-agile replenishment system.

1. Introduction

Armed forces around the world traditionally prefer a 'just in case' scenario for stocking of ammunition and spare parts (Taylor and Tatham, 2008). This leads to large stockpiles, resulting in larger inventory procurement and inventory carrying costs. The army supply chains are always under pressure to improve the cost efficiency during the periods when they are not in action (Tatham, 2006). However, when the army goes to war/missions, reliability and availability of the equipment becomes paramount. The supply chain is expected to be agile, fulfilling the demands of the armed forces, in an environment of

constant and unpredictable change (Maskell, 2001). These two are contradictory requirements that the spares supply chain of the Army must fulfil, i.e. it must save money in the peacetime while ensuring a minimum level of availability and must ensure high mission reliability (achieved by a certainty of supply) in the wars.

Lean and agile supply chain concepts have been extensively researched in academia and practised in the industry. Lean is a concept, a methodology, a way of working; it is any activity that reduces the waste inherent in any business process (Smith and Hawkins, 2004). Leanness of supply chain will inherently result in reduction of costs. On the other hand, Agility is defined as ability to accelerate the activities on critical path and time-based competitiveness (Kumar and Motwani, 1995). In other words, agile organisations are able to compete on the basis of time compression (Yusuf et al., 1999). Aitken (2000) proposed that it is possible to reap benefits of both lean and agile concepts and they can co-exist. Krishnamurthy and Yauch (2007) brought out that lean and agile can co-exist and they illustrated it by using data from a company in the USA. Agarwal et al. (2006) used analytic network process to integrate various criteria of decision making and concluded that leagile is a better SCM strategy than lean or agile. A methodology to marry lean and agile has been illustrated by Towill and Christopher (2005) where they have segregated the activities in time and in geographical space. The methodology has been explained in the context of the healthcare industry in the UK. Aronsson et al. (2011) proposed implementation of a leagile process strategy to improve supply chain performance. To summarise the arguments above, Lean supply chain will benefit the organisation by cutting waste and hence saving money. Agile supply chain will ensure better availability and reliability through an assured spare parts supply in an unpredictable environment like war. These two are contradictory requirements that need to be met from the supply chain. Both these contradictory requirements can be met by separating them in time. The best fit concept to cater for contradictory requirements from a supply chain during war and peace is to have a dynamic time-separated Lean- Agile spare parts replenishment system i.e., a supply chain that is lean during peace and agile during war (Sharma and Kulkarni, 2016). The working of the system in lean and agile mode and its switch from one mode to another will occur with the changing of a number of decision variables. The description of these decision variables can be read in Sharma and Kulkarni (2016).

It is essential to evaluate the current spare parts replenishment system of the Army in order to ascertain the suitability of it to be lean at one time, agile at other; and also to have a capability to make the switch from one state to another. This paper attempts to ascertain the extent of this capability through means of a survey questionnaire. In section 2 of the paper, the attributes of a good lean, agile and a system capable of making the switch are highlighted from the review of the literature. We derive certain deductions from the literature review which emphasize the attributes that a good organisation must have. In the next section, we describe the methodology adopted in this research in detail. In section 4, we discuss the results of the survey and ascertain the status of the current spare parts replenishment system of the army. The paper then homes on to the problem areas that are preventing it to be an optimal system. The survey is summarised in section 5. In section 6, the paper is concluded with a critical assessment of the current situation.

2. Literature Review

This section describes the literature that lists the attributes of a good organisation that holds inventory. The literature review was carried out and the major attributes of the organisation were classified into four major categories as given below.

- Forecasting
- Order tracking and Warehousing
- Distribution and Inventory Control
- Human behavioural issues and Organization

As we are dealing with the problems of Inventory management and replenishment of spare parts in the army, the first three of these categories were selected. In addition to this, an army is people intensive and study of the traits of the people and organisation assumes greater importance. Therefore, a literature review was also carried out in regard to Human behavioural issues related to the management of inventory and organisation. Subsequent paragraphs deal with each of these categories separately with certain important deductions from each of the topics listed at the end. These deductions then become the framework on which the current system of spare parts replenishment of the army is to be evaluated.

2.1. *Forecasting*

Forecasting is an important facet of an effective supply chain. The forecasting of spare parts becomes even more critical as their demand is uncertain and lumpy. Wang and Syntetos (2011) highlighted that spare parts demand is stochastic either in terms of demand interval or demand size, depending on the type of maintenance being carried out. Boone et al. (2008) conducted a research using Delphi technique on senior service part managers to conclude that demand forecasting is the key challenge in service parts management. Better forecasting techniques might reduce safety stocks and thus might reduce costs without reducing service levels (Romeijnders et al., 2012). There are a number of Standard forecasting methods for spare parts, such as exponential smoothing and moving average, as well as specialized methods such as that by Croston (1972). Exponential smoothing in particular is a very robust forecast method that is able to adapt quickly to changes in the demand process. Croston's method, however, has proven itself more accurate than both exponential smoothing and moving average method for demands that are intermittent. There have been a number of attempts made by various authors to improve upon the Croston's method of forecasting of spare parts (Willemain et al., 1994; Romeijnders et al., 2012; Syntetos and Boylan, 2001; Teunter and Sani, 2009).

Chase et al. (2009) in their white paper have listed certain characteristics of industry leaders. According to the authors, leaders are more likely to use demand analytics and reporting (e.g., simulation, what-if analysis and scenario planning tools). Best-in-class organizations consistently shared many characteristics like ability to include causal factors (e.g., weather, natural disasters, competitor actions, etc.) into demand forecasts. Further in that paper, they highlighted that forecasters can't rely exclusively on historical patterns as a good predictor for the future, hence the increased focus on effective, real-time access to consumption data for more accurate demand forecasting and planning. Leading companies use integrated collaborative forecasts with customers. Resounding consensus emerged across all industries that "access to timely consumer data and new product forecasting were their biggest challenges to effective demand management". Lockamy and McCormack (2004) emphasize the requirement of advanced SCM practices, such as collaborative forecasting and planning with customers and suppliers. Lee et al. (2000) pointed that by letting the supplier have visibility of point-of-sales data; the harmful effect of demand distortion can be ameliorated. Chen et al. (2000) indicated that providing each stage of the supply chain with complete access to customer demand information can significantly reduce increase in variability of the

orders placed by the retailer. From the literature the following deductions emerge very strongly:

Deduction 1. Organisations with accurate and scientific forecasting have an advantage over others.

Deduction 2. Inclusion of causal events like impending training exercises, general mobilisation, etc into forecasts will yield more accurate results.

Deduction 3. Collaborative forecasting (of material supply units with equipment user unit) and visibility of point-of-sales data (real time spare parts consumption data from the workshop that is carrying out repair) yields more accurate results.

Deduction 4. Real time access to consumption data will lead to more accurate forecasting.

2.2. Order Tracking and Warehousing

Uses of modern technologies like RFId, bar coding and Warehouse Management Systems (WMS) have eased the problems like inventory inaccuracies, product misplacement etc. associated with warehousing (Sahin, 2004). Bar codes, sensors and/or RFID are used for track and trace functionality throughout all supply chain processes (supply, manufacturing, distribution) (Heinrich, 2005). RFId combined with other systems is becoming the basis for new solutions contributing to a better management of supply chains in terms of cost reduction and improvement of customer service levels (Sahin, 2004). Benefits of using RFID include the reduction of labor costs, the simplification of business processes and the reduction of inventory inaccuracies (Rekik et al., 2008). A reason leading to the out-of-stock issue is the factor related to store shelving and replenishment practices in which products ordered are in the store but not on the right shelf. These factors may be related to shelf space allocation, shelf-replenishment frequencies, store personnel capacity, in store execution errors, etc (Vuyk, 2003). The potential benefits of RFId tagging of individual items is huge because the identity, location and authenticity of these items can be easily monitored, thus resulting in increased efficiency and reduced costs. (Lee et al., 2005; Inventory record inaccuracy, the discrepancy between the recorded inventory quantity and the actual inventory quantity physically present on the shelf, is a recurring occurrence of often considerable proportions (Thiel et al., 2009). The literature review leads to the following deductions:

Deduction 5. Inventory record inaccuracies will lead to overstocking / stock-outs.

Deduction 6. Use of technologies like Bar Codes, RFId and Warehouse Management System (WMS) will result in better management of supply.

2.3. *Distribution and Inventory Control*

A good distribution and Inventory control system leads to an efficient system and satisfied customers. Lateral trans-shipment is one such strategy of distribution that has a positive impact on a supply chain. Chiou (2008) highlights this as "*One strategy in SCM to have an impact on cost, service level, and quality, commonly practiced in multi-location supply chain systems facing stochastic demand, allows movement of stock between locations at the same echelon level or even across different levels".* Ross (2002) describes enabling visibility to inventory as a real process value that needs to be achieved**.** Real time communication and Supply Chain Visibility are indicators of higher maturity (www-scf.usc.edu). Selective Inventory Control not only streamlines the inventory but is also helpful in reducing it to a significant level (Bhatia, 2008). Meredith (1987) pointed out that local firms offer better service, are innovative, respond quicker and provide customization and variety. Perry and Sohal (2000) also identify Supply from Local resources as a good Quick Response practice. Sheffi (2001) summarised the solutions to the supply chain problems. The author highlighted that the problem can be tackled by focussing on known solutions, i.e., (a) improvement in shipment visibility, (b) improved collaboration between trading partners and across enterprises, and (c) better forecasting through risk-pooling methods. Vendor Managed Inventory (VMI) is a tool widely used in industry to cut costs and increase efficiency. Evidence has shown that vendor-managed inventory (VMI) can improve supply chain performance by decreasing inventory levels and increasing fill rates (Yao et al., 2007). Achabal et al. (2000) stated that VMI system reduced inventory costs for the supplier and the buyer and improved customer service levels, such as reduced order cycle times and higher fill rates.

Deduction 7. Lateral Trans-shipment of spare parts (from one workshop to other) will lead to cost reduction (Lean).

Deduction 8. Local suppliers could offer quicker service at a reduced rate.

Deduction 9. Visibility of inventory will make the supply chain both lean and agile, thereby reducing costs and increasing satisfaction.

Deduction 10. Selective Inventory Control will lead to a lean supply chain.

Deduction 11. Vendor Managed Inventory (of commercial off the shelf equipment) leads to reduced inventory costs and improved service levels.

2.4. Human Behavioural Issues and Organisation

Human Behaviour and Organisational culture greatly influence the direction of an organisation. Employee Involvement schemes have significantly improved operational performance in many businesses (Hanna et al., 2000). Various authors have highlighted the importance of motivation of workforce, technical competence and multi-skilling (Dench, 1997; Hopp and Van Oyen, 2004; Thakkar et al., 2009). In regard to the workforce, Herzenberg et al. (1998) pointed that workforce agility may provide wide range of benefits such as quality improvement, better customer service, learning curve acceleration, economy of scope and depth. Training activities not only develop employees and improve their skills and abilities but also enhance their satisfaction with the job and their commitment to the organization (Harel and Tzafrir, 1999). In addition, HRM practices such as development oriented appraisal and comprehensive training show a significant positive relationship with organizational commitment (Paul and Anantharaman, 2004). The following deductions emerge from the review of the literature:

Deduction 12. Technical competence and multi-skilling of the workforce will lead to a better organisation.

Deduction 13. A mechanistic design of organisation will lead to easy implementation of policies.

Deduction 14. Continuous and periodic training of material handlers helps keep them motivated.

Deduction 15. Development oriented appraisals increase organisational commitment.

The deductions arrived at have been taken from the literature reviewed which is summarised below as table 1.

Table 1 : Summary of Literature Review

Ser No.	Attribute	Deduction	Literature
1	Demand Analytics and Reporting	Deduction 2	Chase et al., (2009)
2	Inclusion of causal factors into forecasts	Deduction 2	Chase et al., (2009)
3	Integrated collaborative forecasts with	Deduction 3	Lockamy and McCormack, (2004), Lee et al., (2000), Chen et al., (2000)

4	Scientific demand forecasting	Deduction 1	Chase et al., (2009), Croston (1972), Willemain et al., (1994), Romeijnders et al. (2012), Syntetos and Boylan, (2001), Teunter and Sani, (2009)
5	Visibility of Point - of - Sales data	Deduction 4	Lee et al. (2000)
6	Customer demand visibility	Deduction 4	Chen et al. (2000)
7	Vendor Managed Inventory	Deduction 11	Achabal et al., (2000), Yao et al., (2007)
8	Use of RFId, Bar Coding etc.	Deduction 6	Heinrich, (2005), Sahin, (2004), Rekik et al., (2008), Lee et al.,
9	Correct Warehousing	Deduction 5	Sahin, (2004), Rekik et al., (2008), Vuyk, (2003)
10	Fewer Random yield problems	Deduction 6	Bollapragada and Morton, (1999), Vuyk, (2003)
11	Lateral inventory trans-shipment	Deduction 7	Chiou et al., (2008)
12	Development oriented appraisals	Deduction 15	Paul and Anantharaman, (2004)
13	Comprehensive training	Deduction 14	Paul and Anantharaman, (2004), Harel and Tzafrir, (1999)
14	Technical competence of employees	Deduction 12	Thakkar et al., (2009), Dench, (1997)
15	Multiskilling of workforce	Deduction 12	Hopp and Van Oyen, (2004), Herzenberg et al. (1998)
16	Motivation of employees	Deduction 15	Harel and Tzafrir, 1999)
17	Mechanistic design of organization	Deduction 13	Sherehiy et al., (2007)
18	Inventory Visibility	Deduction 9	www-scf.usc.edu/ SCM_CMM.pdf, (Lee, 2004)
19	Selective inventory control	Deduction 10	Bhatia, (2008)
20	Employee involvement	Deduction 14, 15	Hanna et al., 2000)
21	Proximity of suppliers	Deduction 8	Perry and Sohal, (2000)

3. Methodology

The literature review described in the preceding paragraphs revealed certain attributes of a good system. The next step was to measure the current system based on these identified attributes and to know how effective/ineffective the system is. The research methodology is described in figure 1. On identifying the attributes from the literature, a survey questionnaire with detailed interview with people associated with the field of military logistics was carried out to arrive at the current state of the system in vogue. This step resulted in identifying the deficiencies in the current system.

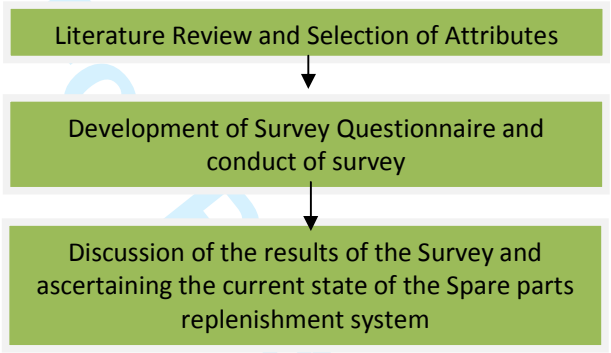

Figure 1 : Research Steps

3.1. Development of Questionnaire

Once the attributes were identified, two things were required. First, it was necessary to know as to where the current system stands on these attributes. This was necessary to gauge the capability of the present system plainly on these attributes. The step after that would be to decipher if the current system is lean, agile or something of both. In order to do the first step, a questionnaire with 61 questions based on the selected attributes from literature review was framed. The questionnaire evolved by Delphi technique over three consultation rounds with experts in the field. As pointed out by Rowe and Wright (2001), structured group of individuals takes more accurate decisions than unstructured group, or for that matter mere gut or intuition. Delphi method is one such structured communication technique that uses a group of experts to arrive at better results (Dalkley and Helmer, 1963).

The technique uses a group of experts to give their opinion on a matter in at least two rounds. There is a feedback given to these experts after the first and subsequent rounds.

The feedback helps the panel revise their decisions in light of the facts presented as feedback and the group converges to a common consensual decision. The survey consisted of both closed and open questions. In addition to answering on the likert scale, the respondents were given a choice to spell out the reasons for their choice. The respondents could choose from one of the many reasons listed, or could give their own new reasons as well. It was an explanatory survey in which the causal relationships between the variables were being searched. The survey was a classic cross-sectional research design that collected data at one point in time from a sample selected to represent the population of interest at that time. Table 2 below is an extract of the survey questionnaire. Detailed survey questionnaire is attached as appendix to the paper.

Table 2 : Extract of Survey Questionnaire

Forecasting						
S No	**Description**	**Likert Scale**				
1.	Do you use a scientific method for forecasting?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) There is no provision to do scientific forecasting. (b) The method exists but we don't use it because (i) It is too complicated. (ii) It is a lengthy and time consuming method. (iii) It doesn't give very accurate results. (iv) We don't feel like doing it. (v) We don't know how to use it. (vi) (c)						
2.	Are forecasts accurate?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) The forecasting methodology is not good enough. (b) Methodology is good but the analysis is difficult. (c) It is difficult to feed the data into the forecasting method hence wrong results. (d) Wrong data gets fed due to lack of training of operators. (e) Wrong data gets fed due to carelessness of operator. (f)						
3.	Do you communicate the forecasts to all the	Always	Mostly	Frequently	Some-	Never

	stakeholders?				times	
Specify reasons if the answer to above question is not "Always" (a) There are no provisions that exist to communicate the forecasts. (b) Provisions exist but communication means do not exist. (c)						
4.	Do you consider forthcoming events to modify your forecasts?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) There are no provisions to include forthcoming events into forecasts. (b) Personnel responsible to make forecasts are not aware of the forthcoming events. (c)						
5.	Do you include inputs from other stakeholders before making forecasts?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
6.	Do you get timely inputs from other stakeholders?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Means of Communication are slow and not in real time. (b)						

3.2. Testing the survey for errors

Once the questionnaire was designed, it was necessary to guard the conduct of the survey against common errors. Before doing that, as the *unit of analysis* in our case were individual managers, it was necessary to confirm if the sample chosen was appropriate to respond to the survey (Pinsonneault and Kraemer, 1993). The respondents chosen were both senior level and mid level managers with sufficient experience in the field, and hence were considered appropriate for the survey (Malhotra and Grover, 1998). The survey used multiple respondents from the same company and the questionnaire was followed up with interviews with the representatives, it is considered as sufficient form of triangulation to cross-validate the results. In the next step, the *content validity* was checked by the experts who assessed the appropriateness of the questions to the overall aim of the survey. The selection of the respondents (Only senior and mid level managers) is indicative of the fact that *sample frame error* was omitted. This sample frame is actually involved in spare parts management in the army and is therefore appropriate to answer the survey. The 55 respondents selected were

also representative of the ratio of senior and mid level managers (11:44 or 1:4) and hence the *error of selection* of the sample from within the sample frame was also avoided. Another thing to note is that 100% of the respondents actually replied to the survey, leading to a census and hence there was no need to calculate *non-response bias.* Once the causality in the variables was established, a few selected relationships were tested for internal validity through follow up interviews. Malhotra and Grover (1998) stated that the single most important factor in establishing adequate power for a test is sample size and a sample size of at least 100 is desirable. The survey conducted in this paper was done only on 55 respondents and is therefore likely to introduce *statistical conclusion error* owing to a small sample size. The authors, however, decided to keep the sample size small as this survey was complicated and not based on factual data. It was deliberately decided to restrict the survey to face to face interviews with a smaller sample and to avoid mailing questionnaires to a larger number of respondents that may introduce other errors.

3.3. Data Collection

The survey was conducted on 55 respondents. 11 of these respondents have an experience of 17-19 years in the field of military logistics and spare parts replenishment. Remaining 44 respondents have an experience of 6-8 years in the same field. As the respondents belonged to two clear separate categories of seniority, it was necessary to carry out tests to ascertain if the two groups had significantly different means. This was done in this study using *t*-test analysis on Excel. A two-sample Student's *t*-test assuming equal variances was performed to test the hypothesis that the means of responses by the senior level managers were equal to those of mid level managers. The null and alternate hypothesis were

$H_0 = \mu_1 = \mu_2$ (The population means of the two groups are same)

$H_{alt} = \mu_1 \neq \mu_2$ (The population means of the two groups are different)

The *t*-test was performed on six major criteria which were tested in the questionnaire. The results of the test are enumerated in table 3.

Table 3 : *t*-test on the two groups of managers

Criteria	Measurement Scale	Overall Mean	Senior level Mean	Mid level Mean	df	t_{stat}	$t_{critical}$	Significance
Scientific Forecasts	Always-1 Never-5	3.14	3	3.18	18	0.47	2.1	0.64
Forecast Accuracy	Always-1 Never-5	3.47	2.9	3.6	14	2.05	2.14	0.0588
Correctness of Stock Checking	Always-1 Never-5	3.83	4.27	3.72	22	1.85	2.07	0.076
Inventory Visibility	Always-1 Never-5	4.2	4.09	4.22	16	0.57	2.12	0.576
Training of Workforce	All-1 None-5	1.98	1.54	2.09	25	2.67	2.05	0.013
VMI	Always-1 Never-5	4.16	4.27	4.13	18	0.59	2.1	0.55

The results of the test reveal that in all criteria but one, t_{stat} is less than $t_{critical}$. Also, the significance value of these criteria (except one) is more than 0.05. Both these comparisons lead us to accept the null hypothesis that the population means of the two samples are not significantly different. The two groups of respondents, namely senior level and mid level managers exhibit different means for one criteria, i.e, "Training of Workforce". This may be due to the subjectivity of the criteria. The senior level managers seem more satisfied than the mid level managers with respect to the training of the workforce. This can also be due to some disconnect between the senior level managers and the workforce. Mid level managers deal more intimately with the workforce, and therefore are a little more dissatisfied with the level of training of the workforce.

The survey questionnaire was distributed to the respondents while they had got together for a training course. The reasons for the conduct of the survey and the methodology being adopted were explained to the respondents. Various queries of respondents were answered on the spot by the authors. The survey was concluded with personal interview with the respondents. The results of the study are enumerated in the succeeding paragraphs.

4. Discussion of Results

4.1. Forecasting

A total of 6 questions related to forecasting methodology currently in use in army and its efficacy were asked in the survey questionnaire. Questions were designed incremental in nature, i.e., From "Do you use forecasting?" to "Is the methodology scientific?" and finally to "Are the forecasts accurate?" Once it was established that forecast accuracy was suspect, further questions tried to establish the real reason for the inaccuracy. The results of this section of the survey bring out the fact that forecasting for spare parts in the army has a lot of deficiencies. The present system is neither collaborative nor real time. Summary of the results are as given in figure 2. A few important conclusions that are derived from the survey are as follows:

- Current methodology not considered scientific by most.
- Forecasting accuracy is very suspect.
- Forthcoming events are not considered while making forecasts, hence the adverse effect on accuracy of the forecast.
- Inputs from the stakeholders are not always considered while making forecasts.
- Inputs from the stakeholders are not in real time.

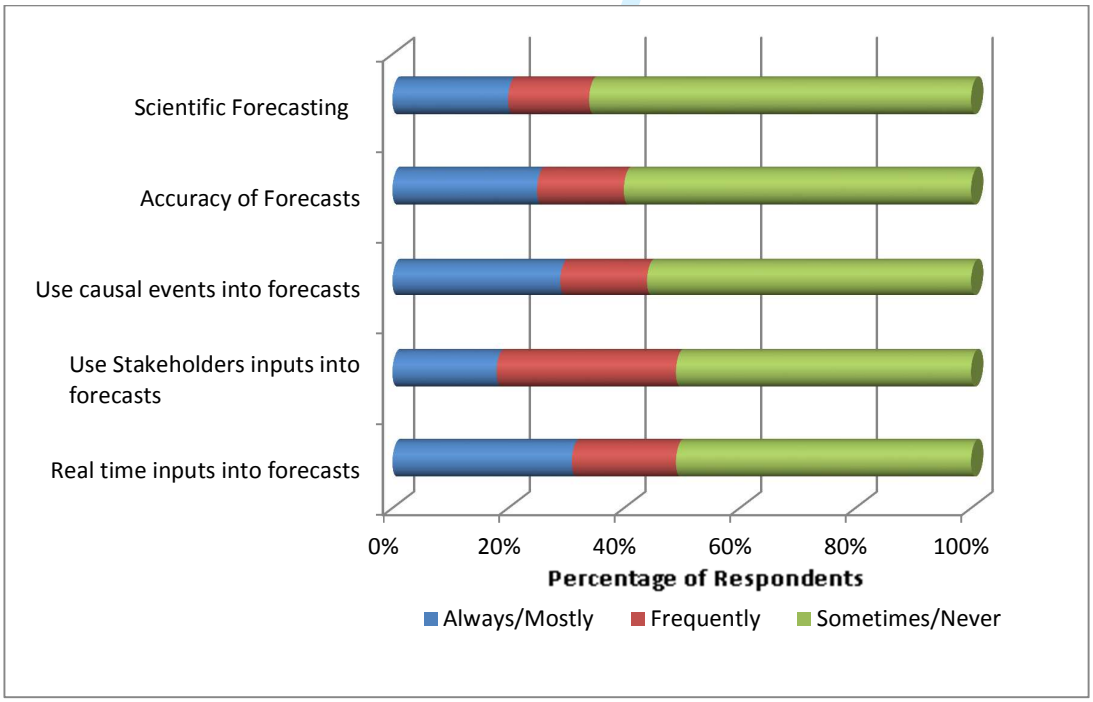

Figure 2 : State of Forecasting in the Current System

4.2. Ordering, Order Tracking and Warehousing

The survey questions in this section were aimed at bringing out the issues related to ordering process. Large majority of respondents feel that the orders travel slow and have errors in them. On further questioning, it emerged that the orders are made on paper, requiring authorisations through signatures and they travel through post. There are also problems of real time tracking of these orders, resulting in errors being discovered late and therefore resulting in stock outs/ excess inventory. Figure 3 brings out the results of the survey

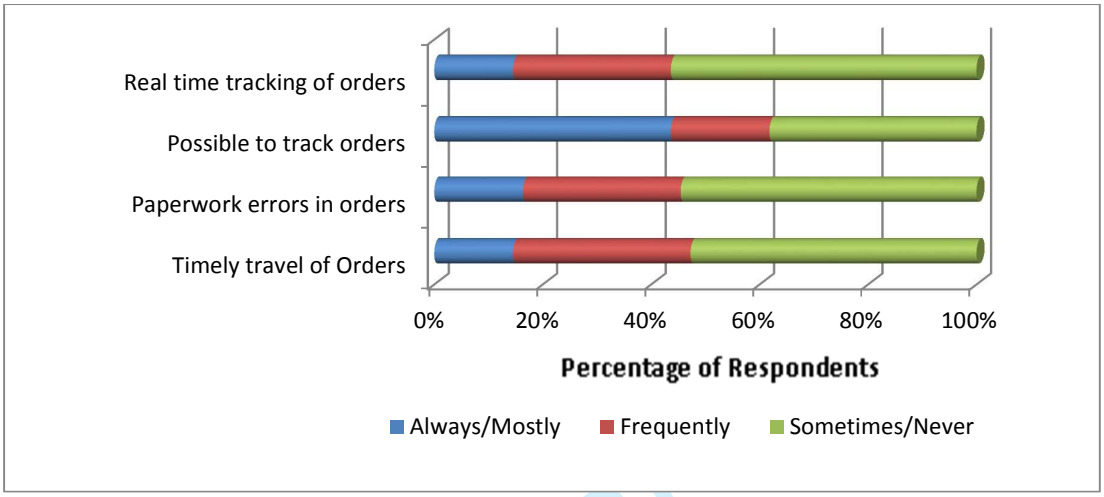

Figure 3 : Order Tracking

Good warehousing practices help in increasing the effectiveness of the system. The survey questions were directed towards highlighting the state of technology being used in storage. The responses clearly indicate that very little technology is being used in warehouses, thereby resulting in inaccuracies during stock checking exercises (Figure 4). More than 60% of the respondents felt that there are problems in the way the spare parts are stored. 85% of the respondents were concurrent with the view that the process of stock checking was cumbersome, time consuming and error prone (Figure 5). Technology is a big enabler that will help in making a system both lean and agile. A clear lack of technological solutions in use emerge out of the survey and are indicative of a field that can immensely benefit if RFId, Bar Codes and Warehouse Management Systems are brought into practice.

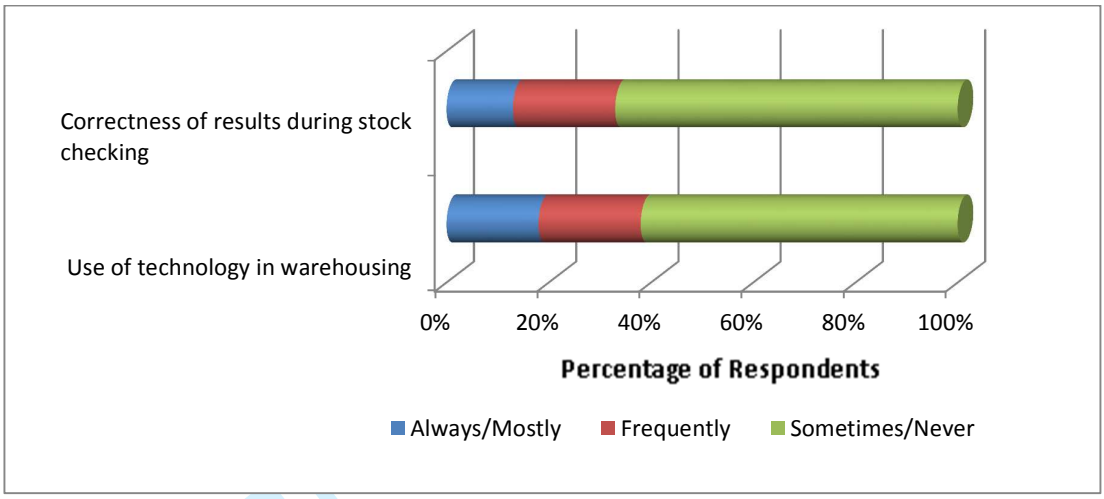

Figure 4 : Warehousing

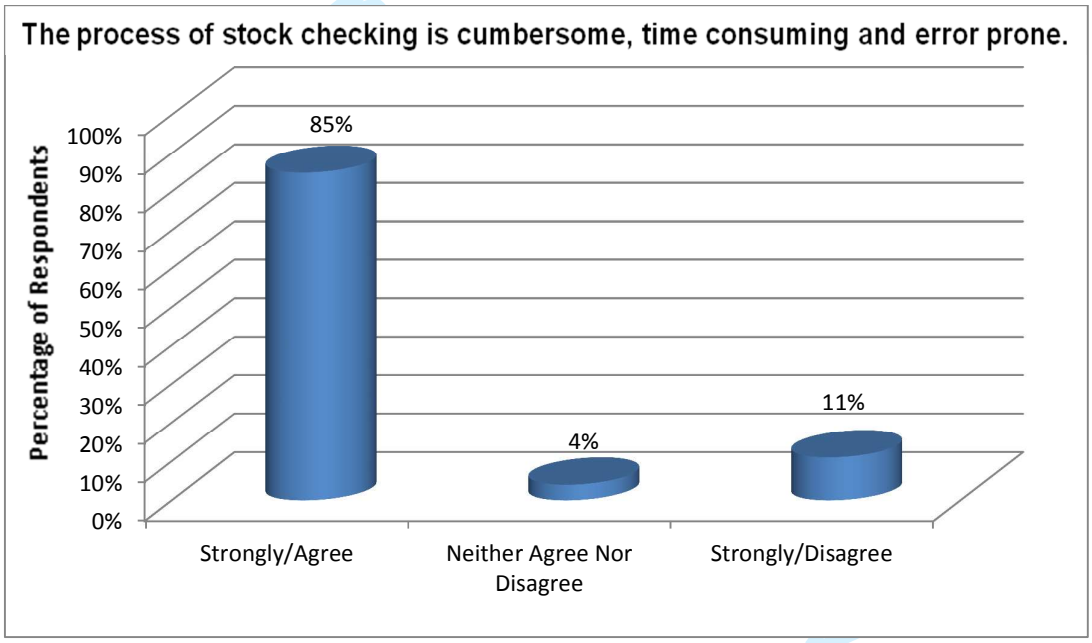

Figure 5 : Process of Stock Checking

4.3. Distribution and Inventory Control

A total of 20 questions were designed to cover these two important aspects of the supply chain, i.e., distribution and inventory control. An important aim of the section was to deduce if there is an asset visibility or not, hence the question "Is the level of stocks held in warehouses at different levels visible to all? More than 85% of the respondents indicated that there are no provisions to see the level of stocks, thereby making it difficult to laterally trans-ship the spare parts from one warehouse to other. More than 80% also responded

likewise when asked about the capability to laterally trans-ship the spare parts (Figure 6). The current system though uses selective inventory control and local suppliers, but has not found use of Vendor Managed Inventory in any way. Vendor Managed Inventory is an effective tool for inventory management and we recommend it to be used only in the lean mode of operations due to the fact that it will be not be prudent to put the civilians in the harm's way when the operations/war is going on.

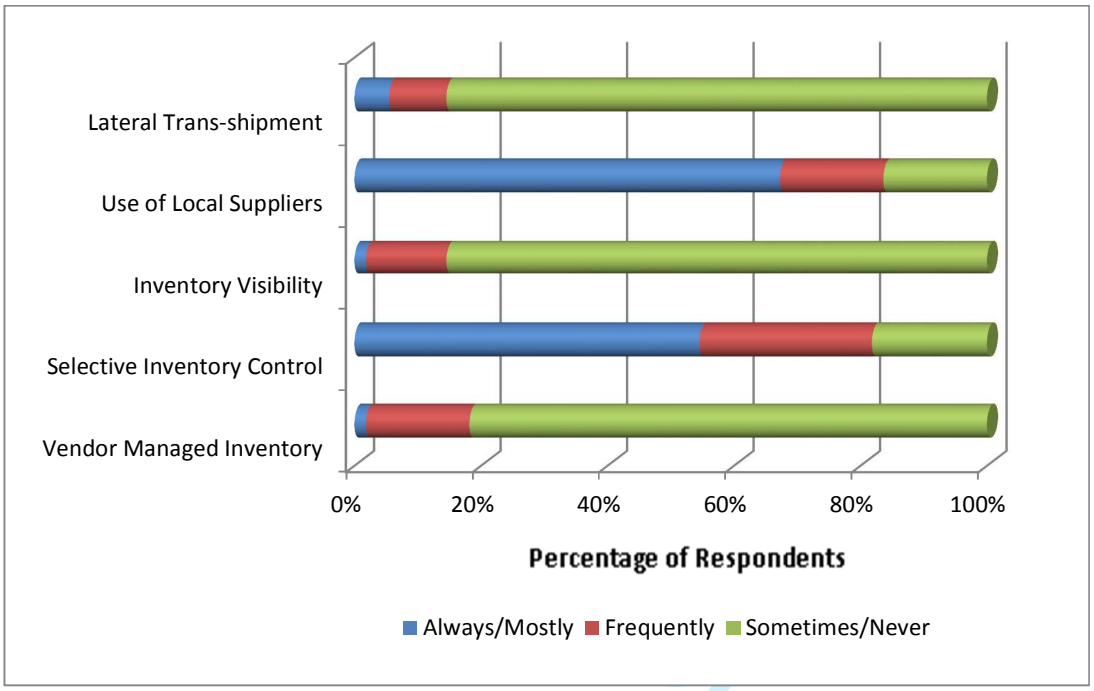

Figure 6 : Distribution and Inventory Control

4.4. Human Behavioural Issues and Organisation

While other sections of the survey aimed at problems related to technology and processes, these two sections were aimed at bringing out the characteristics of people and organization. Army being a people intensive centrally controlled organization, these sections assumed greater importance. Questions like "How much of the workforce is technologically aware of the latest developments in their field?", "How much of the workforce is multi-skilled?" and "How much of the workforce do you train and upgrade?" were aimed at revealing the levels of training, motivation and technical competence of the workforce, a factor very significant when a system is being changed after years of existence (Figure 7). On the other hand certain questions were framed to highlight the kind of organization that we have. These

were "Is the communication between entities Hierarchical? (As against Network Communication)" and "Is the control Centralized?" These were aimed to gauge whether the organization is capable of carrying out change in policies and implement them till the last level (Figure 8). This capability assumes importance as the research is proposing to change the spare parts replenishment into a dynamic lean-agile system.

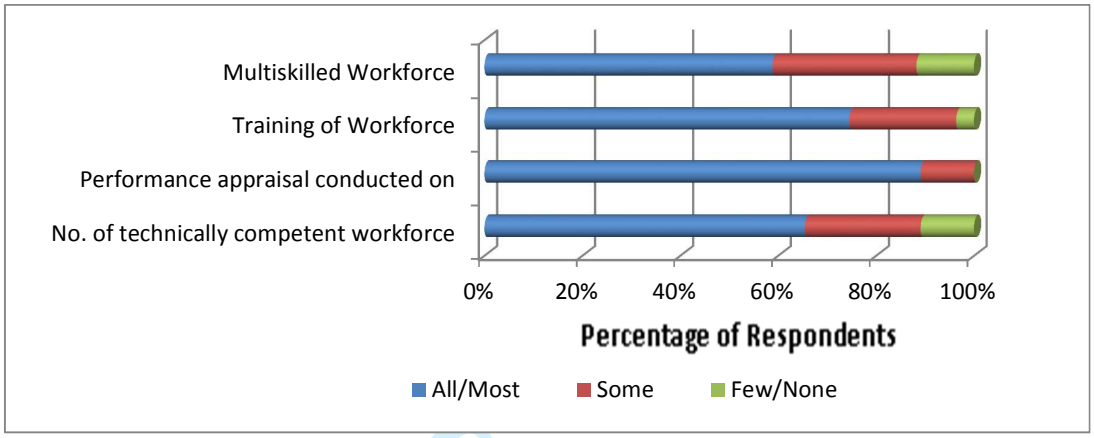

Figure 7 : Human Resources Management

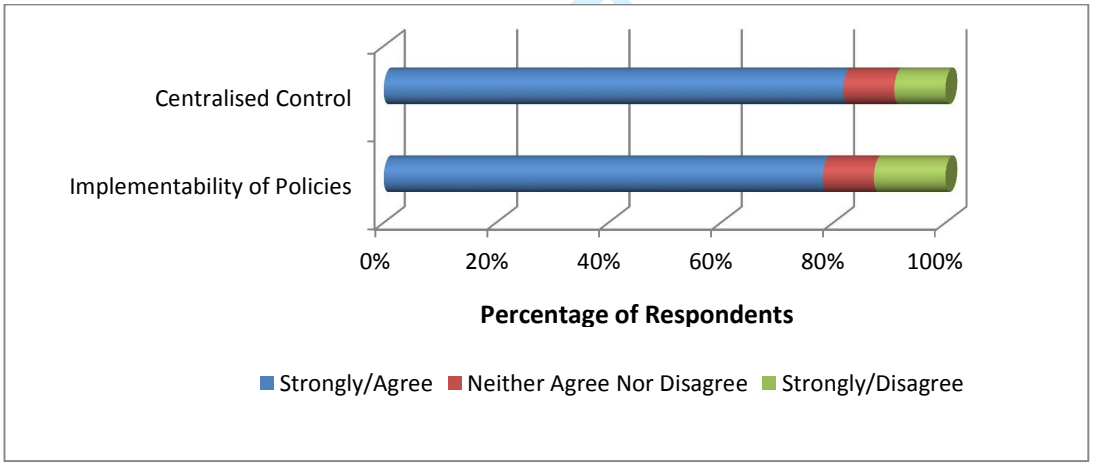

Figure 8 : Organisation Characteristics

5. Summary of the Survey

The survey throws up a number of issues that need attention in order to implement any dynamic lean - agile spare parts replenishment system. The dynamic system will work only in

presence of a networked information exchange platform which helps take instant logical decisions. Some of the insufficiencies of the current system are summarised below.

- The current demand generation and its communication to other stakeholders is based on paper. It takes days, and sometimes weeks, for the demand to travel. This, when coupled with other problems like lost in transit, paperwork errors etc., is a major risk for the system. The consequences can vary from delayed supply to wrong supply or sometimes even no supply. This makes the whole system slow and lethargic, leading to a lack of agility.
- As is evident from the survey, there are no provisions to monitor the demand. Tracking is not real time and it takes months to realize that something in the provisioning process went wrong. The consequences of the risk remain the same, wrong/delayed/no supply of spare parts. This has an adverse impact on both the lean and agile supply chain.
- As the survey shows, information in the current system travels at the speed of paper and not more speedily through an integrated networked system. This perpetual lag in flow of information affects decision making. Limited data analytics being used in the current system lacks accuracy as the input being fed is delayed. This lag in information flow also adds indirectly to the lead time for supply of spare parts.
- An absence of real time accurate information flow results in inaccuracies of the decisions. These inaccuracies have both short term and long term effect on the supply of spare parts. Wrong decisions lead to surplus inventories/ stock outs, both of which are not acceptable in a dynamic lean-agile switch scenario.
- The most glaring drawback in the current system that is emerging out of the survey is a lack of visibility of stocks. Workshops and depots are not aware of what is available with others and therefore, the demands perforce follow a strict vertical channel. There is no scope of horizontal communication and consequently, no lateral trans-shipment can take place. Asset visibility which will be brought in with implementation of an integrated IT network will help obviate this problem. This will greatly enhance both leanness and agility of the system.

The survey also brings out the strengths and the weaknesses of the current system. These are the attributes which will make or mar the chances of successful implementation of a dynamic lean-agile system. The strengths of the system are given below in succeeding paragraphs.

- Organization is hierarchical with centralized control. This, in turn, means that implementation of policies will flow top down and will be complied with.
- A very large percentage of respondents have indicated that nearly all/most of the workforce is regularly trained and upgraded. A large number of the workforce is technologically aware of the latest developments in their field and is technically competent too.
- There are processes in place to continuously monitor and evaluate the performance of the employees.
- The survey also indicates that the organization is capable of implementing policies and standards.
- As most of the respondents have replied, an integrated IT network is a felt need of the organization. The people are expecting and welcoming such an initiative.

The present state of the system can therefore be summarised as follows:-

- **The system is not lean.** This is owing to lack of real time flow of information, slow processing of demands and absence of processes like VMI, 3PL etc.
- **The system is not agile.** Information flow is slow, and hence there are delays in decision making. Data analytics is not employed and hence predictions are difficult. Lack of stock visibility adds to system inefficiencies.
- **The system is not flexible to make a switch from lean to agile and vice versa.** Lack of an integrated IT network not only delays the decision making, but also implementation of these decisions, whenever taken.
- Organization and People are geared up for a change. Small alteration to them can be made in order to implement a dynamic lean-agile system. However, Technology and Processes require a major overhaul. An integrated IT network in conjunction with introduction of revised processes will yield better results.

6. Conclusion

There are a number of inadequacies in the current spare parts replenishment system in the army that have emerged in this survey. These shortcomings do not come to fore as the buffers present as inventory hide them. Absence of a sound forecasting mechanism, lack of inventory visibility, absence of an ICT network etc. make the replenishment system dependent on *just in case* mode of inventory stocking. There is a need for the Army to switch to a smarter system

that gives good results both in peace and in war. Both Lean and Agile supply chain concepts and a combination of the two have been practised in the industry. Army, as an organization needs to learn it from them and exploit the benefits of a hybrid lean-agile system. This paper has identified the shortcomings of the present spare parts supply chain of Army and suggests areas that need to be focussed on in order to implement a time separated lean – agile spare parts replenishment system. Further work is required to lay down the precise roadmap to implement such a system.

Both in lean and agile modes of replenishment, it is essential that a mechanism be developed that can forecast the requirement of spares to a certain degree of accuracy. A number of tools exist in industry and academia today that can foretell the impending failures and list out spare parts that will be required to either avoid that failure from occurring (prevention) or rectify the failure if it has already occurred (correction). Army's requirements in this regard differ greatly from the industry because of the dynamicity of the employment of army equipment in significantly diverse situations. Future work is required to bring out a tailor made forecasting methodology for the spare parts of the Army which accommodates all three situations, i.e., peace, training exercise and war.

VMI as a concept has found many takers in the industry and it is considered an important lean tool. Army has a large number of commercial off the shelf (COTS) equipment which can easily be managed by the original equipment manufacturers (OEM). Many of the vehicles in the army are from manufacturers who supply similar/same vehicles to civilian end user too. Their own distribution network to manage the authorized dealership workshops of civilian use is presently existing and working with good efficiency. Outsourcing of supply of spares of such COTS equipment can be done, however after customizing the requirements to suit the dynamic nature of the army supply chain. Further research is required in the field.

The survey has confined itself to the study of the current system with *Human Behavioural Issues and Organisation* as one of the important section. This has been done deliberately owing to the fact that Army is a human-intensive organisation which often lays more emphasis on *man behind the machine* rather than the machine itself. Judgemental aspects of humans come into play in producing forecasts and deciding on replenishment decisions, and therefore this section has been given equal importance along with *Forecasting, Order tracking & Warehousing* and *Distribution & Inventory Control*.

The study does suffer from errors owing to a small sample size of 55. It is however reiterated that the authors felt that as the survey was subjective and descriptive, personal interviews with the respondents with follow up questions will reveal greater information that is closer to the reality. The length and complexity of the survey would invariably result in different errors if the questionnaire is mailed to the respondents, without the authors having an opportunity to ask further questions. A larger sample size would definitely be more desirable in such a survey.

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Forecasting

S No	Description	Likert Scale				
1.	Do you use a scientific method for forecasting?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) There is no provision to do scientific forecasting.
(b) The method exists but we don't use it because
(i) It is too complicated.
(ii) It is a lengthy and time consuming method.
(iii) It doesn't give very accurate results.
(iv) We don't feel like doing it.
(v) We don't know how to use it.
(vi)
(c)

2.	Are forecasts accurate?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) The forecasting methodology is not good enough.
(b) Methodology is good but the analysis is difficult.
(c) It is difficult to feed the data into the forecasting method hence wrong results.
(d) Wrong data gets fed due to lack of training of operators.
(e) Wrong data gets fed due to carelessness of operator.
(f)

3.	Do you communicate the forecasts to all the stakeholders?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) There are no provisions that exist to communicate the forecasts.
(b) Provisions exist but communication means do not exist.
(c)

4.	Do you consider forthcoming events to modify your forecasts?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) There are no provisions to include forthcoming events into forecasts.
(b) Personnel responsible to make forecasts are not aware of the forthcoming events.
(c)

5.	Do you include inputs from other stakeholders before making forecasts?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a)

6.	Do you get timely inputs from other stakeholders?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) Means of Communication are slow and not in real time.
(b)

Ordering

7.	Is order quantity based on forecast and inventory levels?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always" (a) Ordering process has no provision to consider forecasts and inventory levels. (b) Measurement of inventory levels is a problem. (c)						
8.	Is release of orders in time, i.e. are you always able to place orders/demands in time?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) There is no system that prompts when a particular order/ demand is due. (b) There are no computerised means to place the orders. (c)						
9.	Do the orders reach the stakeholders in time?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Means of communication are slow. (b) Sometimes, the orders get lost in transit. (c)						
10.	Are there errors (paperwork errors) in the orders?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) These errors are due to lack of training of persons making the orders. (b) Errors due to carelessness/ lack of motivation. (c) Errors are due to lack of technological solutions. (d)						
11.	Is it possible to track the orders?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
12.	Is it possible to track the orders in real time?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
13.	Do you receive correct items as per orders?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Human errors at Depot level due to lack of training. (b) Human errors at depot level due to lack of motivation. (c) Error due to lack of technological solutions (d)						
Warehousing						
14.	Is it possible to relocate the warehouses?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
15.	Is getting decision to relocate quick and easy?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						

16.	Do facilities (Vehicles, Land, and Covered Accommodation) required to relocate exist?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
17.	Is it easy to relocate once instructions have been received?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
18.	Is the storage and retrieval of items after relocation as systematic as it was before?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Lack of technological solutions i.e., RFId, Bar Codes, Warehouse management system, etc. (b) Time inadequate to arrange the warehouse after re-location. (c)						
Distribution						
19.	Do you laterally trans-ship items in case of requirement, i.e., from one workshop to other, or one depot to other?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) There are no provisions to trans-ship the spare parts. (b) I am not aware what stores are held where. (c)						
20.	Do you have fastest means of transportation of items at your disposal?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
21.	Do you have cheapest means of transportation of items at your disposal?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
22.	Are the lead times constant?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Forecasting is not accurate. (b) Suppliers are not able to handle demands. (c) Suppliers are global and hence, supply chain is prone to disruptions. (d) There are delays because the process of supply of spare parts has flaws.						
23.	Are the suppliers local?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						
Human Resources						
24.	How much of the workforce do you train and upgrade?	All	Most	Some	Few	None
Specify reasons if the answer to above question is not "All" (a)						

25.	How much of the workforce is technologically aware of the latest developments in their field?	All	Most	Some	Few	None
Specify reasons if the answer to above question is not "All" (a) Low education standards of the workforce. (b) Lack of good training. (c) Training infrastructure and training programmes are outdated. (d)						
26.	How much of the workforce is multiskilled?	All	Most	Some	Few	None
Specify reasons if the answer to above question is not "All" (a) Multi-skilling as a concept is not accepted to the organisation. (b) Workforce is not competent to handle requirements of multiskilling. (c)						
27.	How much of the workforce is technically competent?	All	Most	Some	Few	None
Specify reasons if the answer to above question is not "All" (a) Low IQ and Education standards of workforce. (b) Lack of good training. (c)						
28.	How much of the workforce is involved in continuous improvement of processes and facilities?	All	Most	Some	Few	None
Specify reasons if the answer to above question is not "All" (a) Lack of motivation of workforce. (b) Existing processes are so lengthy that the workforce doesn't have time to do so. (c) Feedbacks from the workforce are not considered important. (d)						
29.	Do you evaluate the performance of your workforce?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a)						

Organisational Structure and Culture

30.	Is the communication between entities Hierarchical? (As against Network Communication)	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
31.	Is the control Centralized?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
32.	Is the Coordination between sub departments formal?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
33.	Is the decision making process centralized?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
34.	Is the top management committed to the cause of achieving required flexibility in supply of items?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
35.	Does the organisation has wherewithal to implement policies and standards?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
36.	Is a process of audit and review in vogue in the organisation?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree

37.	Is the process of review effective i.e., are stockouts questioned?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Stockouts are not recorded. (b)						
38.	Is the process of review effective, i.e., Is excess / obsolete inventory questioned?	Always	Mostly	Frequently	Some-times	Never
39.	Does the organisation have a procedure of evaluation of cost/benefit tradeoffs?	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Maintenance Effectiveness and Efficiency						
40.	Is the quality of repairs good?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Quality of spare Parts is not good. (b) Repair manpower is not trained adequately. (c) Lack of good repair facilities. (d) Excessive load on the repairer. (e)						
41.	Is the recycling of faulty assemblies on time?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Processes are not efficient. (b) Mode of transportation of assemblies is not fast. (c) Lack of capability to repair due to lack of (i) lack of Skilled manpower (ii) lack of repair Infrastructure (iii) lack of Spare parts (iv) Overloading						
42.	Are assemblies that are beyond economical repairs discarded?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) There is no policy to do so. (b) There is no methodology to decide what is BER. (c)						
Engineering Solutions and Redesigning						
43.	Are basic design flaws taken up by engineering solutions department for redesigning?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) The department lacks capability to solve all the problems. (b) The department is understaffed and does not have the capacity to undertake all design modifications. (c)						
44.	Do modifications address the problem in its entirety?	Always	Mostly	Frequently	Some-times	Never
45.	Does the engineering solutions department have the capability to provide solutions that it is meant to?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) Lack of technical ability and skills.
(b) Lack of funding.
(c) Lack of policies to have academic institutions as partners in projects.
(d) Policies of joint collaboration with academic institutions are complicated and hence deter participation.
(e)

46.	Does the user implement suggestions/guidelines provided by engineering solution department?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) Solutions are not always effective.
(b) Solutions are not implementable.
(c) Solutions are not communicated to all stakeholders.
(d) There are no checks in place to ascertain if everyone has implemented the required modifications.
(e)

Inventory Control

47.	Is selective inventory control exercised?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) Inventory management persons have no knowledge of selective inventory control techniques.
(b) There are no reviews to check if it has been done.
(c) There are no provisions to do it.
(d) It doesn't yield substantive results.
(e)

48.	Is the control effective?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) Not measurable, hence do not know.
(b)

49.	Do you use concepts like Level of Repair Analysis (LORA) do decide whether to repair or replace?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) No such technique is used in the organisation.
(b) The methodology exists but is very complicated.
(c) Methodology doesn't yield good results.
(d) I don't know how to do it.
(e) I don't want to do it.
(f) Nobody cares if I do it or not.
(g)

50.	Do you regularly check the level of stocks to match it with the quantity on books?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) No such checks exist in the system.
(b) Very difficult to carry out these checks.
(c)

51.	Are the results of stock checking correct?	Always	Mostly	Frequently	Some-times	Never

Specify reasons if the answer to above question is not "Always"
(a) Stock checking is not done seriously.
(b) Book keeping is a problem.
(c) Lack of technological solutions lead to mistakes.
(d)

52.	The process of stock checking is cumbersome, time consuming and error prone.	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
Specify reasons if the answer to above question is not "Always" (a) Human errors due to carelessness. (b) Lack of technological solutions. (c) Human errors due to lack of training. (d)						
53.	Inventory control is a difficult task owing to lack of standardisation.	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
54.	Top Management is working to resolve the problem of non standardisation.	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
55.	Majority of the equipment has a modular design.	Strongly agree	Agree	Neither agree nor disagree	Disagree	Strongly Disagree
56.	Is modularisation an agenda while selecting new equipment for induction?	Always	Mostly	Frequently	Some-times	Never
57.	Is the level of stocks held in warehouses at different levels visible to all?	Always	Mostly	Frequently	Some-times	Never
Specify reasons if the answer to above question is not "Always" (a) Lack of technological solutions (b)						
58.	Does the organisation follow the concept of Vendor Managed Inventory (VMI)?	Always	Mostly	Frequently	Some-times	Never
59.	Till what levels is Vendor Penetration present?	All	Most	Some	Few	None
60.	Does an emergency response system for supply of spare parts exist?	Exhaustive	To a great extent	Somewhat	Very Little	Not at All
61.	Is this emergency response plan effective?	Always	Mostly	Frequently	Some-times	Never

Name (Optional) _____

Experience in years _____

Field of Expertise **Material Supply / Repairs and Maintenance/ Other**

Email Address _____