AFTER-SALES SERVICE PARTS SUPPLY CHAIN SYSTEM IN OEM TELECOM FIRMS

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ABSTRACT

After-sales service is an important source of revenue and profit for OEM (Original Equipment Manufacturer) Telecom firms. A good performance of the after-sale service provides a competitive advantage for the OEM firm against their competitors in case of customer acquisition or even retention. However the design and management of the after-sales service is a challenge for many reasons, e.g. obviously the OEM can't produce services in advance of demand, the only thing they can do is just make predictions about product failure. In the other hand, the supply process is also a source of variability. The match demand and supply process is another challenge. In order to tackle and mitigate this kind of problems this paper shows how to build the system of the after-sales service supply chain going from strategic business plan, master production plan for spare parts and labor, safety levels of inventory in consignation to customer, etc. Also we emphasize the information technology and coordination that need to exist within the different echelons into the supply chain, so this can be viewed as a system which included the repair process, the delivery process and the collect process.
Keywords: Service Parts, Supply Chain, Production Systems.

INTRODUCTION

After-sales service represented a reasonable amount of revenue for telecom OEMs (Original Equipment Manufacturer)[1] that offer spare parts management and repair to their customers. The consulting firm *Accenture* (Dennis & Kambil, 2003) mentioned in general that "after-sale parts and service are the new frontier of competitive differentiation and profit enhancement, offering nearly double the profit potential of first time product sales". Similar evidence can be found in a previous study made by the Wharton School (Cohen *et al* 1999), which revealed that gross margins for after sales service in the computer industry in North America in 1998 generally exceed 50 percent for enterprise system[2], and around 20 percent for non-enterprise systems[3].

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[1] Whenever we refer to OEM into this paper, we are talking about telecommunication OEMs *e.g.* Alcatel-Lucent, Ericsson, Cisco, etc. which would be considered the supplier.
[2] Enterprise refers to high end products such as main frames, midrange systems, servers and data centers (see Cohen et al 1999)
[3] Non-Enterprise refers to products such as PCs, desktop systems and peripherals (see Cohen et al 1999)

On the other side, in a customer perspective, mobile and wireline operators[4] need to ensure a high level of network availability and performance while reducing cost[5]. This is a challenge aim, so in some cases the operators outsource the maintenance services, allowing them focusing more on their core businesses and becoming more flexible, as well as reducing cost. O'Shea (2006) stated that the annually savings in OPEX costs are up to 10 until 15 percent. According with the consulting firm *Pyramid Research* (2006), 47 percent of the mobile operators, outsource some or all of their spare parts management activities while wireline operators appear to be least open to outsourcing spare parts management, with 79 percent indicating that it is conducted by internal staff. In 2007 *Pyramid Research* conducted a global and regional survey on mobile operator's spends on services. The category "spare part management, repair and replacement" shows an increase trend for the next years in outsourcing spend, going from $3904 US M in 2005 up to $5616 US M in 2010, i.e. 43.8 percent higher in 2010.

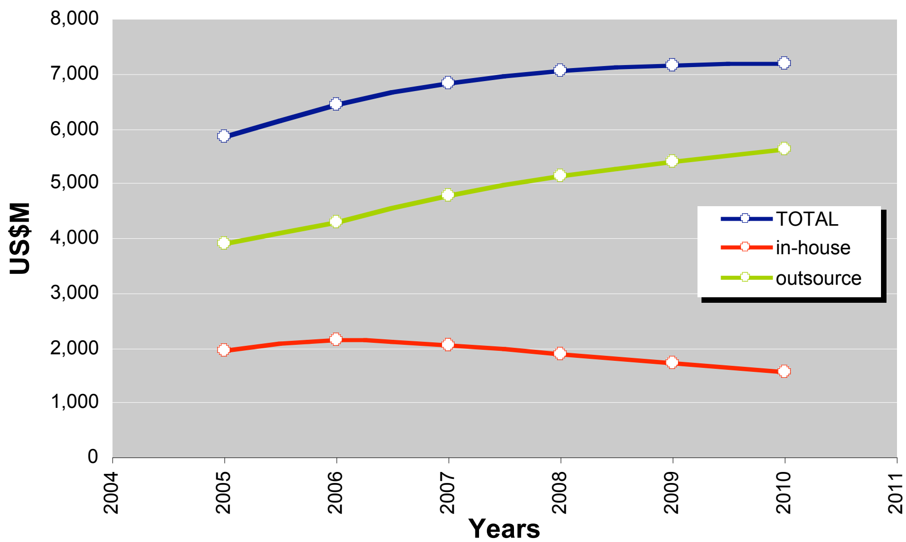

Figure 1. Global Repair and Replacement and Spare Parts Provision and Management Spend

And at region level the next table 1 indicates that Western Europe and Asia Pacific show stronger tendency toward outsourcing spare parts services than the other regions.

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[4] *E.g.* Verizon, AT&T, Telmex, Telefonica, etc. which would be considered the customer.

[5] Maintenance and operation network cost is divided in CAPEX (Capital Expenditure) and OPEX (Operational Expenditure), CAPEX is related with spare investment, building, etc and OPEX for transportation, human labor, etc.

Table 1. Repair and Replacement and Spare Parts Provision and Management Spend by Region

Region	US$M	_2005	_2006	_2007	_2008	_2009	_2010
Africa Middle East	Total	466	566	632	667	682	684
	In-House	155	189	190	180	166	150
	Outsource	311	377	442	487	516	534
Asia Pacific	Total	1,683	1,889	2,034	2,125	2,169	2,180
	In-House	561	630	610	574	527	477
	Outsource	1,122	1,259	1,424	1,552	1,642	1,704
Central Eastern Europe	Total	397	447	467	476	479	480
	In-House	132	149	140	128	116	105
	Outsource	265	298	327	347	363	375
Western Europe	Total	1,811	1,892	1,941	1,963	1,974	1,977
	In-House	604	631	582	530	480	432
	Outsource	1,207	1,261	1,358	1,433	1,495	1,545
Latin America	Total	504	580	624	648	659	661
	In-House	168	193	187	175	160	145
	Outsource	336	386	437	473	499	517
North America	Total	996	1,069	1,123	1,162	1,189	1,206
	In-House	332	356	337	314	289	264
	Outsource	664	712	786	848	900	942

The numbers and trend in spare parts management outsourcing contracts shown in figure 1 and table 1, represent a growing opportunity in first place to give a high reliable after sales service and in second place to obtain a revenue streams and market for OEMs. Of course, capture this market is not easy and the OEM after-sales service parts supply chains need to face different challenges *e.g.* customer needs and behavior, logistic management, budget limit, IT infrastructure, product upgrades, phase-out products support, warranties, repair, customer support, customer installed base visibility, long supply and repair lead times, intermittent and probabilistic demand, integration and coordination between different echelons within the supply chain, variability across the entire supply chain, etc.

In the realm of service parts management, relationships between OEMs and operators are often established through service agreements that extend over a period of time. The details of these service agreements vary in nature depending in customer requirements e.g. response time, customer budget, etc. Then customer concern would be high network availability and OEM challenge would be to allocate and optimize resource to commit the agreement.

In a typical supply chain in this industry, circuit packs are produced at one or more factories, shipped to a distribution center and local warehouses for intermediate storage, ready to support customer demand. As circuit packs are remanufactured parts, the supply chain must also include remanufacturing vendors, so defective parts can be integrated into the spare pool after a recovery process as shown in figure 2.

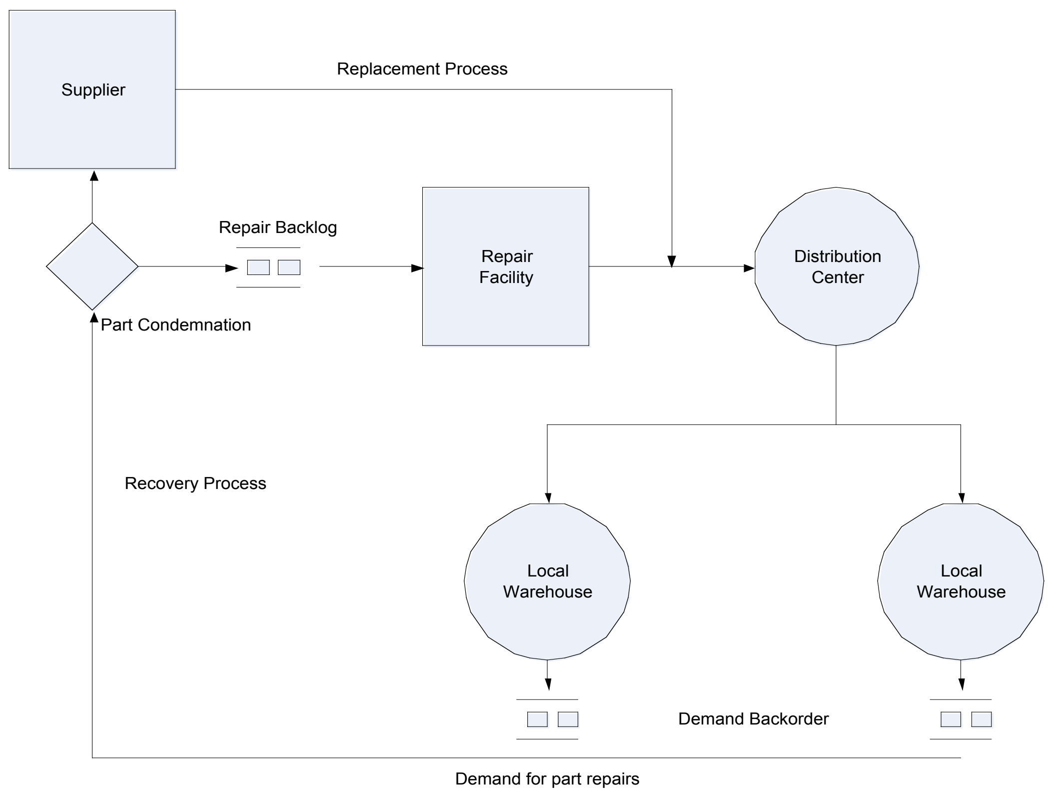

Figure 2. Multi-echelon distribution network with repair and pooling.

The design and model for the after-sales service parts supply chain can not comes from the manufacturing models as stated by Cohen (2006b) because of the following issues:

Table 2. Two supply chains compared Manufacturing versus After-Sales Service

Parameter	Manufacturing Supply Chain Management (MSCM)	After-Sales Service Supply Chain based on corrective maintenance	Based on predictive and preventive maintenance
Nature of demand	Predictable, can be forecast	Always unpredictable, sporadic	Predictable, can be forecast
Required response	Standard, can be scheduled	ASAP (same day or next day)	Standard, can be scheduled
Number of SKUs	Limited	15 to 20 times more	Limited
Product portfolio	Largely homogeneous	Always heterogeneous	Largely homogeneous
Delivery network	Depends on nature of product; multiple network necessary	Single network, capable of delivering different service products	Depends on nature of product; multiple network necessary
Inventory management aim	Maximize velocity of resources	Pre-position resources	Maximize velocity of resources
Reverse logistics	Doesn‘t handle	Handles return, repair and disposal of failed components	Doesn‘t handle
Performance metric	Fill rate	Product availability (uptime)	Fill rate
Inventory turns (the more the better)	*Six to 50 a year*	*One to four a year*	*Six to 50 a year*

According to table 2 column 3 the processes and tools to manage manufacturing goods in a cost effective manner don't work well for after-sale service business on corrective maintenance, however manufacturing processes and tool work perfectly on predictive and preventive maintenance, as shown in column 4, which is the system that offers best level of reliability and quality of after sales services. Indeed it is proposed to implement as soon as possible the Supply Chain Management (SCM) information system adapted to manage preventive/predictive maintenance based on a master produ8ction schedule for spare parts and labor.Storage of SKU's of critical spare parts could be made under the agreement of consigned inventory, with physical location very near the main line equipment or network.

In the after sale services industry there should be one of two fundamentals objectives. One, is to obtain a capability to render a better new service hat can be sold at a profit (capability to serve) and the second, is to improve an existing after sale service so as to improve performance and customer acceptance or reduce cost without sacrifice of customer acceptance either of which would lead to higher profits.

In meeting these challenges, certain authors have addressed this kind of problems. From a mathematical perspective the books of Sherbrooke (2004) and Muckstadt (2005) encompass the more relevant advances to model the system. From a business side, Ray (2004), Cohen (2006a), Cohen *et al* (2006b) discuss and suggest methodologies to properly manage the service supply chain.

The objective of this paper is to show a systemic approach similar to Cohen *et al* (2006a) involving the strategy, tactical and operational planning into an integrated manner, that helps the After-sales service organization to design and operate the supply chain.

AFTER-SALES SERVICE PARTS PROCESSES

For many years, Operators have been installed OEMs equipment over wide geographical regions and not just in-country, either globally, e.g. *AT&T* MPLS network largely built using *Cisco Systems Inc*. equipment, now has 1500 owned service nodes in 80 countries and remote access in a total of 148 countries, and still announced further network expansion[6]. Figure 3 illustrates current *AT&T* global network.

[6] Source: AT&T web page http://www.corp.att.com/globalnetworking/docs/att_goes_global.pdf

Figure 3. AT&T global networks[7].

To keep operating the global network at peak performance around the clock is a big challenge. As indicated in figure 1, the tendency is to outsource these tasks with OEMs through maintenance contract agreements. Basically those agreements specify what would be the service/recovery network availability response time and at what service level agreement (SLA) that would be committed e.g. 90%, 95%. OEMs offer different services portfolio and they can be summarized in three levels as shown in figure 4.

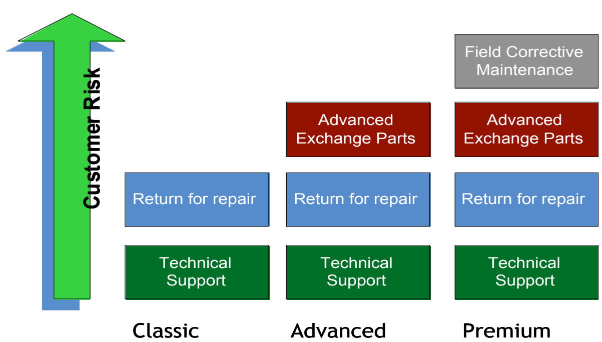

Figure 4. Different OEM services versus Operator risk

Last figure illustrate how OEMs assume more customer risk as they provide higher quality services. This paper will focus only on spare management and repair service only, i.e. *Return for Repair* (*RfR*) and *Advanced Exchange Parts* (*AE*). The other two are more related with technicians and monitor maintenance systems. In an *AE* service the OEM ship the spare part to the Operator in advance of receipt defective part with a same day or next day response time. Once the OEM received the defective part back then he use to repair the part and restore the spare pool. In practice, this contract is use basically for

[7] Source: AT&T web page http://www.corp.att.com/globalnetworking/docs/global.pdf

critical items[8]. In a *RfR* service, the Operator send a faulty part to the OEM, then the commitment is to return a good part to the Operator with a specify Turn-Around Time (TAT) e.g. 30, 60 or 90 days. Depending of repair TAT and contractual TAT the OEM needs to balance the differences between these two TATs through the use of a spare pool, e.g. if 30 days is contractually established and the repair TAT is 90 days, then the OEM will need to allocate some spare pool to meet customer agreement.

If a stock need to be positioned for *AE* and for some *RfR* contracts, then the question is of: what parts? And where to allocate them? In order to answer this question, the Operator installed base and where is it physically installed need to be listed at part level into the contract. Here it is very important to verify that the parts are current manufacturing available, otherwise sourcing phase-out items could be more problematic and there is not a guarantee to really get them as spares.

The next figures 5 and 6 illustrate the process that parts follow for the two different services. The numbers indicates the sequence of steps that each part follows into the supply chain. Color green arrows mean good parts and gray faulty parts. The figures also place insight in how the supply chain system is made of a set of interacting business partners sharing a particular purpose within a boundary. The most important supply chain system characteristic is the holistic properties (Jackson, 2003) i.e. the holistic properties are frequently grater than the arithmetic sum of the supply chain partners.

The use of 3PL within the supply chain to support warehousing and transportation operations is becoming more prevalent for the successful of service, because they provide flexibility to the supply chain (see Simchi-Levi *et al* 2003 for a discussion of advantages and disadvantages of 3PLs), so this is a common practice in today business operation.

Because of *AE* contracts has the shortest response time and the faulty part should be collect after the delivery of the good one, this kind of agreements are the most difficult to support, i.e. this type of service increase the variability into the supply chain and the response time commitment is more aggressive than *RfR* services.

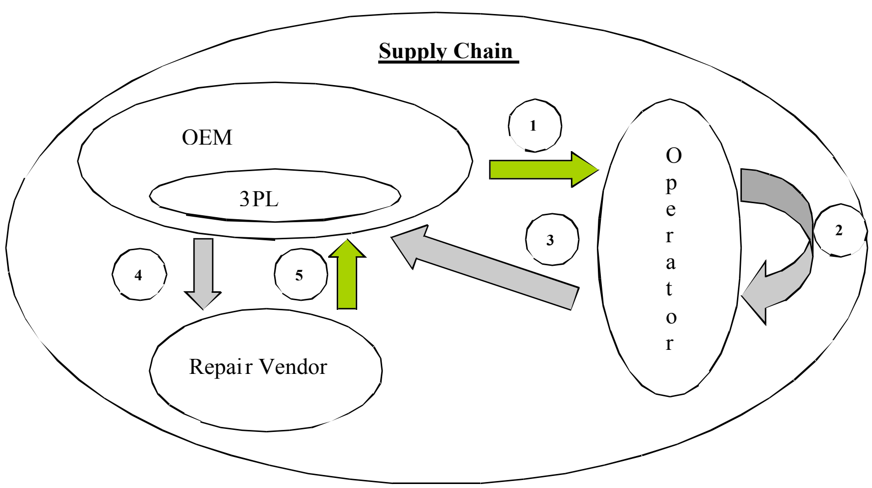

Figure 5. Advance Exchange service process into the Supply chain

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[8] Critical items are those that when failed the effect has a great impact on Operator network availability.

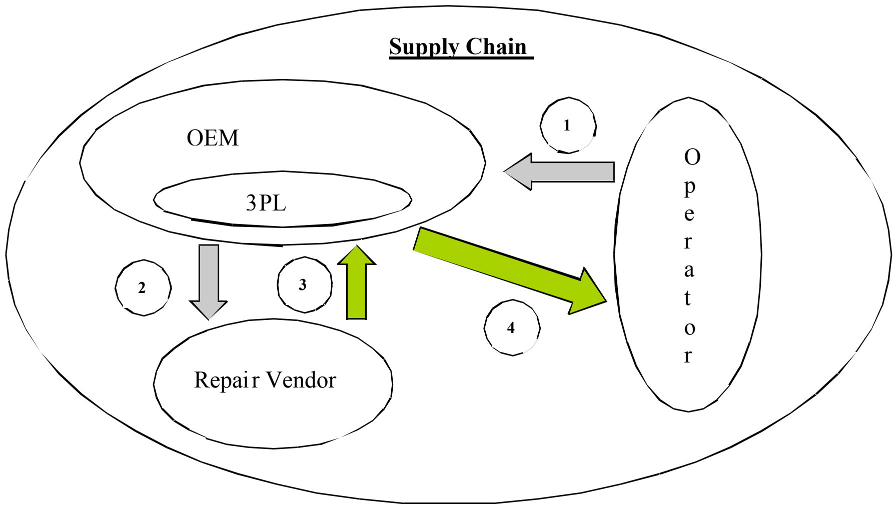

Figure 6. Return for Repair service process into the Supply chain

In both service processes, failures occurrence variability, long repair and transportation TAT, high value spares parts, suppliers management, import/export country regulations, supply chain echelon integration and coordination, information visibility and tracking, budget boundary, customer support group efficiency, are typical issues that makes the challenge to deal with service operation more difficult. The OEM target is to design the supply chain that minimizes system wide cost while at the same time, meet customer agreements, i.e. make the supply-demand process match. Although uncertainty cannot be eliminated, the next section we will explore various approaches that could help to plan the supply chain service going from strategic through the tactical to the operational level.

AFTER-SALES SERVICE PARTS SUPPLY CHAIN DESIGN

In order to tackle the different challenges to support the supply chain, this section deals with the planning steps and information requirements we recommended to design and operate the system. The types of decisions that must be made relating to service parts management and repair can roughly be divided into three planning categories: *strategic, tactical* and *operational* planning. *Strategic* decisions are those that have a long lasting effect on the firm, *tactical* decisions are typically updated anywhere between once every quarter or month and *operational* decisions refers to day to day activity.

Strategic planning issues related with the design of the supply chain are:

a) *Service part portfolio*. Base on *AE* and *RfR* agreements the OEM should obtain information about the installed base of parts that need support, where these are located, the response time and the SLA to commit. In practice it is common to use *AE* contracts for critical parts and *RfR* for non-critical.

b) *Logistic network design.* Configuration network decision of warehouses and repair vendors location can be viewed as forward and reverse logistics network decisions. For forward logistics the objective is to commit contractual response time considering 3PL capabilities and others government or geographical constraints, etc. But the common rule is to set up with the 3PL distributed warehouses to commit *AE* same day delivery parts contracts and a centralized warehouse for AE next day delivery and/or *RfR* service parts contracts (see figure 7). It is recommended to considerer the centralized warehouse as the distribution center for the rest of distributed warehouses. This configuration has proven cost optimality into the supply chain (see the METRIC[9] method by Sherbrooke 2004). Reverse logistic network must consider other elements *e.g.* the transportation cost, the repair capacity, annually average repair demand by location, so the systemwide repair cost can be minimize.

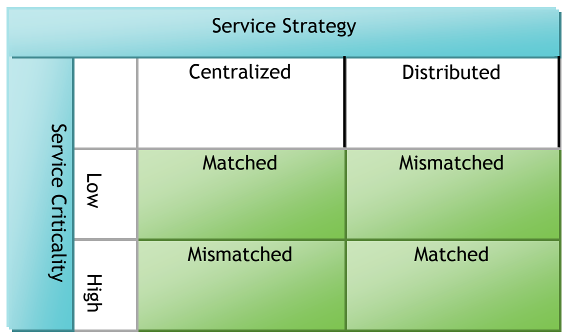

Figure 7. Connecting service strategy with criticality

c) *Master Part File.* This database enables the planning tool and organizations to know part detail information, e.g. phase-out parts, substitutes, descriptions, etc. This part must be included into the IT solution.

d) *3PL alliances.* 3PL arrangement involves long-term commitments related with warehousing, transportation and defective collect process. These alliances allow more flexibility in OEM assets and provide the opportunity to dedicate more to the core business. Simchi-Levi et al (2005) listed the issues and requirements that need to be considered in deciding to contract a particular 3PL: i) know your own cost, ii) customer orientation of the 3PL, iii) specialization of the 3PL and iv) Asset-owning versus non-asset owning 3PL.

e) *Budget.* This issue is considered as a constraint in terms of infrastructure investment.

f) *Master schedule.* For preventive/ predictive maintenance should be agreed between all involved managers from OEM's, customers an 3PL's

[9] METRIC: Multi-Echelon Technique for Recoverable Item Control, is a mathematical model developed by Sherbrooke to manage spare parts by the US Air Force while he was at the RAND Corporation in 1996.

Tactical planning issues:

a) *Demand analysis.* OEMs cannot produce service in advance, only for immediate consumption in response of a failure of the Operator installed equipment. There are two sources of information in order to forecast demand, failure parts records and Mean Time Between Failures (MTBF) by part number. As stated by Trindade *et al* (2005) reliance on the MTBF without full understanding of the implication can result in missing developing trends and drawing erroneous conclusions. The idea is to use Mean Cumulative Functions (MCF) to present effective field data analysis instead which comprehend more the dynamics of demand.

b) *Lead times analysis.* The service supply chain has three different lead times: transportation time, repair TAT and defective collect time just for AE service contracts. The sources of variability in the three cases are different. Transportation time can be affected by international movements and depends on specific country regulations. Repair TAT variability depends on the capacity and effectiveness of the repair installation. Finally Defective collect time variability is link to customer performance. In Frei (2006) this last variability is call "Effort Variability", i.e. "when a customer must perform a role in a service interaction, it's up to them how much effort they apply to the task". To resolve this issue he advises different strategies to pursue better performance, however an analysis need to be done previously to any recommendation. As higher lead time variability into the supply chain the outcome is worse performance. It is very important to monitor and find root causes to reduce as possible this type of variability.

c) *Optimum inventory position.* Once we have the information at the strategic level and the demand and lead time analysis the next step is to calculate the optimum spares pool allocation. During the life of the service agreement the investment on spares could be the highest cost, so it is recommended to use a model *e.g.* METRIC to pursue the objective.

d) *Inventory management.* Of spare parts should include lead time for all spare parts plus all critical related information, such as unit price, unit of measurement , numbers of part, etc.

Operational planning comes once we have the optimal inventory position calculated, for example inventory balances and replenishment, repair and defective collect prioritization, new inventory buys, scrapped analysis, etc. To optimize the cost Muckstadt (2005) constructed base on dynamic programming three different approximations: i) stock allocation model (SAM), which determines how many parts to ship from the distribution center to the distributed warehouses in each period of the planning horizon, the second is ii) the extended stock allocation model (ESAM) which is similar to SAM but now there is a possibility to use an expedite shipment mode from the distribution center warehouse, and the third is iii) extended stock allocation model with repair (ESAMR) that includes the two previous models and the repair parts. The interrelation of the three planning levels and time horizons is shown in figure 8.

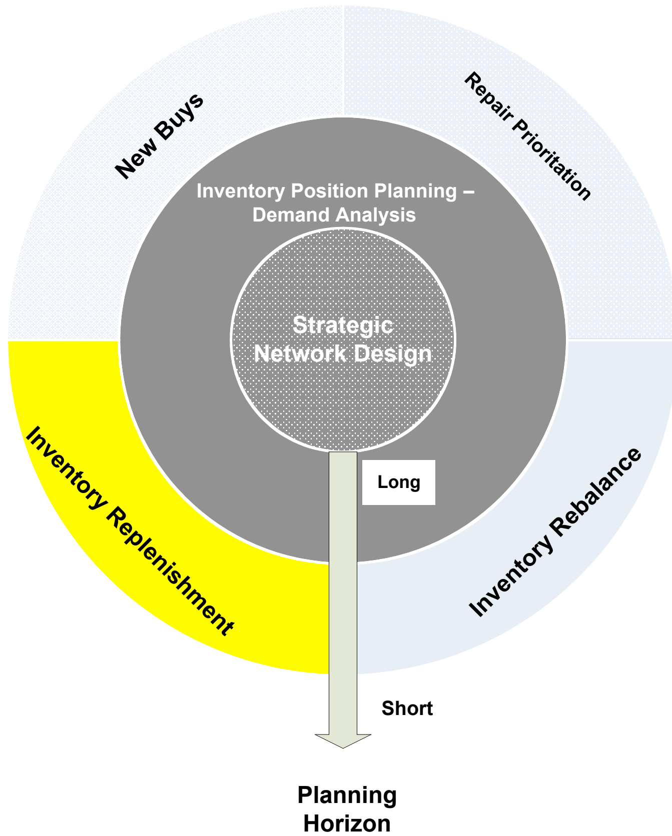

Figure 8. Planning Process.

Solving the problem of managing the inventories requires a probabilistic dynamic representation of the environment. So it is usually to make strategic modification in a long planning horizon, recalculate inventory and demand on a monthly or even weekly basis and plan for inventory allocation daily as well.

Once the supply chain and the services are operating, dynamical metrics (Keep Performance Indicator KPIs) should monitor the customer and supply chain performance. From a customer's perspective, service quality is defined by *delay of the part request* and from the OEM supply chain perspective there are various measurements involve associated with the availability of the service. The principal is *part fill rate*, the fraction of demand for parts that is available in stock at the site receiving the demand.

The successful of supply chain integration stem from the fact of three elements as stated by Lee (2000) information sharing, coordination and organizational linkages between all the partners of the supply chain. Information Technology is a critical enabler of effective supply chain management. To accomplish this, different business systems need to be linked so the information integration can be realized (see figure 9).

Enterprise Resource Planning (ERP) encompasses the different activities into a company and can be considered as the backbone of IT infrastructure. Nowadays ERP systems should organized an enterprise completely according to customer needs, regarding the business environment of the enterprise as a supply chain including, repair vendors, manufactories, 3PLs network, OEM logistics networks and customers (see Zhang *et al* 2006). They do not, however, help answer the fundamental question of what should be made, where, when, and for whom. This is the role played by human planners with the aid of various analytical tools such as decision-support systems (DSS) planning tool. Also it is important to integrate Repair management system, 3PL system and Customer Relations Management (CRM) system information, so the DSS planning system integrate all the information and planning take into consideration the total supply chain. Analyzed data will depend on quality data, also information flow need to be synchronized with material flow.

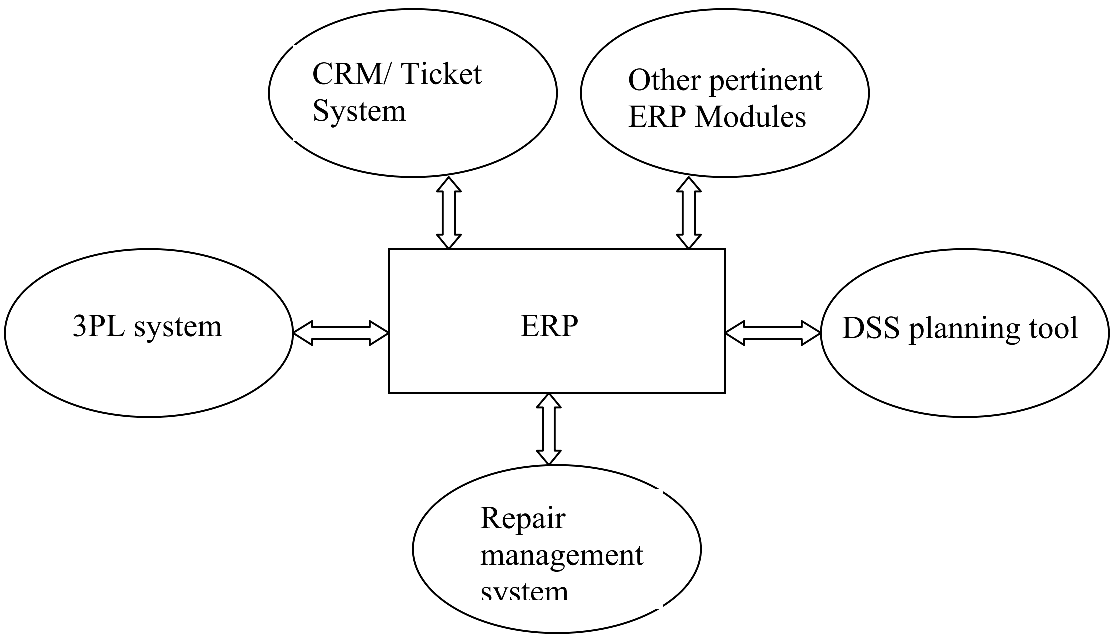

Figure 9. Information integration system.

CONCLUSION

The presented work proposes a systematic approach of how OEM firms can plan the service solution through the supply chain from strategic through tactical and finally operational planning. This solution embraces operation research supply chain models and concepts, the use of IT systems and manager skills focus on service offerings. Although there are great developments in technology and business models, the integration of a global service parts supply chain is still challenging. The new concept in OEM services is Multivendor support, i.e. be a single point of contact to customers, supporting different OEMs products. The risk to handle this service is still higher than the Advance Exchange services because more variability is infected into the processes. The after ales Supply Chain of spare parts and services must be transformed as soon as possible from a 100% corrective maintenance system to a 99% predictive/ preventive maintenance system. Concepts from system theory, knowledge management, complex systems, etc can also be analyzed in a future research to incorporate methodologies or concepts that help better understand the dynamics of the supply chain service part system

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