

Spare Parts Management – An IT Automation Perspective

- Sandeep Kumar

Executive Summary

The criticality of spare parts management in manufacturing and service operations cannot be understated. Given factors like demand unpredictability, part alternates, parts indigenization and tight control on spare parts inventory coupled with high service levels, the imperative to accurately forecast spare part requirements and to optimize on inventory requires significant decision support. Performing on objectives such as these helps improve profitability and achieve strategic goals such as customer loyalty and lock-in. The paper looks at the various facets of spares and service management from primarily a MRO (Maintenance, Repair and Operations) perspective. The paper also examines the space from an automation perspective and suggests an automation approach.

Introduction

The spare parts market represents \$700 billion and 8 percent of the U.S. gross domestic product, according to U.S. Bancorp. And many manufacturers find that margins for services can top 40 percent, whereas margins for finished goods top out at around 13 percent, according to industry estimates.

- *“Keeping an eye on all your parts”*, Heather Harreld

1

Spare parts management is a science and an exact one at that! The trade-off between managing parts inventory vis-à-vis meeting service levels translates into a need for forecasting accuracy, managing parts proliferation and high analytical capabilities. The availability of parts and making equipment fit for operation impacts the maintenance as well as the regular business operations. Equipment downtime is lost production capacity. Current business trends are pushing manufacturers into global operations across procurement, manufacturing, sales and after-sales service. Higher consumer choice and responsiveness to changing demand has imposed a need to integrate and collaborate across the supply chain with particular emphasis. This is probably most true in discrete manufacturing environments with considerable after sales service needs and a huge impact on the spare parts function.

Before discussing the impact, let's define the term “Spare parts” and establish a common understanding. “Spare parts” refer to the part requirements for keeping owned equipment in healthy operating condition by meeting repair and replacement needs imposed by breakdown, preventive and predictive maintenance. The spare part management function is critical from an operational perspective especially in asset intensive industries such as refineries, chemical plants, paper mills, etc as well as organizations owning and operating costly assets such as airlines, logistics companies, etc. “Service parts” on the other hand would refer to the demand for parts imposed by service requirements for equipment owned and operated by customers. The service function is one that is outsourced to a third party aftermarket service provider or one managed by the manufacturer itself.

¹ Excerpt reproduced from the article “Keeping an eye on all your parts” by Heather Harreld by permission from Infoworld (<http://www.infoworld.com/article/02/01/04>)

Given the profitability of the spare parts business, manufacturers are looking towards the spares management function as a vital part of their operations, both from an internal operational perspective as well as from the service perspective. In this paper, we use the terms “Spare part” to connote both spare parts and service parts as applied to a manufacturer handling both internal and external spare and service needs.

Differentiating Spares From Production Parts

A question that often comes up is “Why treat service and spares differently from regular production parts?” The forecasting of spares and service parts as well as the inventory management function is a more complex task because of the following characteristics:

#	Production Parts	Spare parts
1	The demand for production parts is a derived or a dependant demand generated from the production plan and hence is predictable	The demand for spare parts largely depends on the output of preventive and predictive maintenance activities, and is typically based on MTTF (mean time to failure) calculations. Sudden breakdowns due to factors such as wrong operation or failure to perform a routine maintenance activity lead to demand with no assignable predictable causes, thereby imposing a need to maintain buffer inventory.
2	Production parts have a demand based the existence of market demand which is easier to predict	The demand of spares is based on the equipment life cycle and follows the inverted bathtub curve
3	Easier to forecast because of more predictable movement patterns.	The sparse nature of usage/ consumption data makes it difficult to generate statistically valid forecasts for spares.
4	Incidence of alternate parts and common parts is handled through substitution relationships in a Bill Of materials.	The existence of part alternates and common parts across equipment makes inventory management more complex.
5	The component/ part relationships with the supplier are inherently better defined apart from commodity raw materials.	Spares are often procured locally and development of indigenous suppliers makes the analysis of failure dependent on a large set of factors. Managing multiple sources of supply for the same part imposes a need for greater rigor and analysis on service maintenance.
6	The demand for a part or a component is in most cases a derived demand based on the customer demand for the end product; which is relatively simple and based on orders received or forecasted.	Often the demand for a spare arises from an alternate source of failure. To elaborate, a failure of a key on a gear shaft may cause the gear shaft to be replaced as well as the other meshing parts like gears. Likewise, the demand of spares is a function of the equipment life cycle.
7	Production parts are typically the input or output of a production process. Non-availability of input parts can constrain the throughput.	Non-availability of spares impacts the throughput and directly translates into costly machine downtime.

The Need For Focus – Spare Parts Management

The demand driven supply chain story of integrated planning and decision support has been well documented. However, the move to integrated supply chains has not included the service aspects very well and likewise, the integration of execution systems such as plant maintenance systems with planning systems has seldom been focused on. A host of factors are driving the need to take a close look at this vital aspect:

- **Business criticality:** Lowering the cost of operation and improving service levels is the challenge that both plant and service maintenance folks face. The demand for agility and flexibility has led to more sophistication in manufacturing systems with higher part complexity and greater capital investments, calling for better utilization factors and quality service response.
- **Visibility and optimization:** Deployment of spare part inventory happens across locations and one way of controlling the spare part inventory is by taking a global view of inventory and then forecasting demand based on statistically significant data. In service operations, the practice of maintaining multi-echelon inventory calls for optimization on inventory decisions based on need and service response.

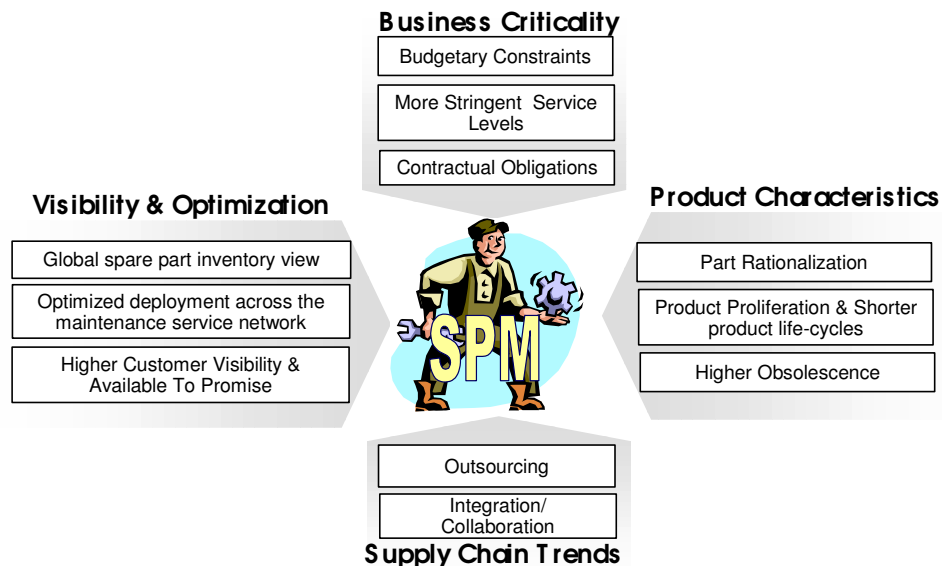
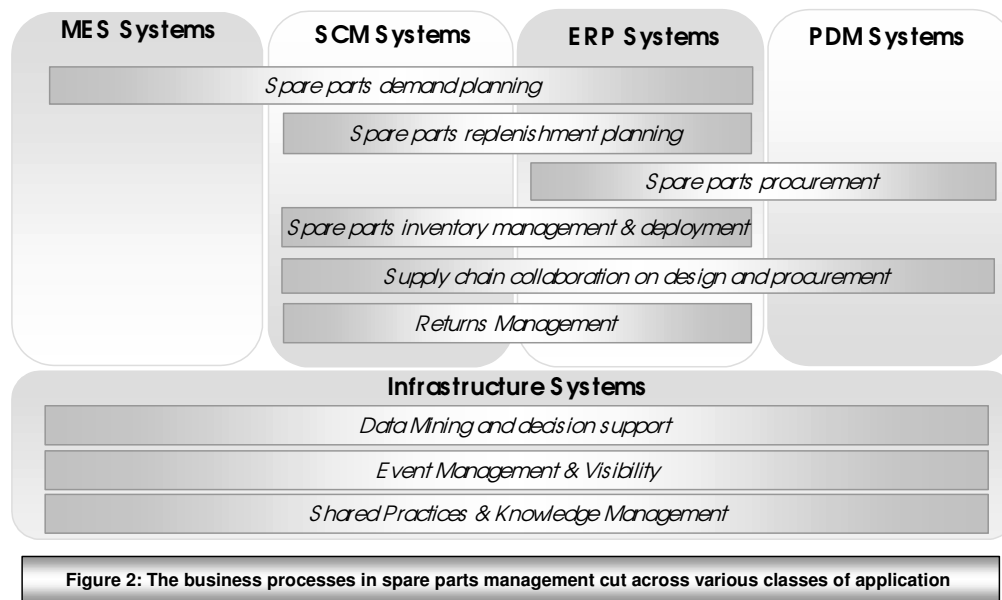


Figure 1: The business needs on spare parts management are manifold...

- **Supply chain trends:** The trend towards outsourcing of service functions has huge ramifications on system support for managing service needs. The operational planning process needs to be closely integrated with the service and maintenance planning functions and in a service provider scenario; it becomes vital that there is integration from both a process and a system perspective. As an example, some operational specifics on what and how a batch of steel plates was made in a hot strip mill in a steel plant needs to be made available to a third party maintenance service provider to predict the maintenance requirements from a activity and a part perspective.
- **Product Characteristics:** The proliferation of parts and products is making equipment manufacturers rationalize and standardize on their parts and components. A rationalization step in the earthmoving industry could be to try and use the same standard set of accessories across all bulldozers manufactured.

Business Processes And Functions In Spare parts Management

Spare parts management involves several business processes that need application support and data from various classes of applications. The prominent application systems that a spare parts management system would need to interface with would include MES systems (manufacturing Execution Systems – systems that cater to maintenance planning and execution, capture of service history, etc. besides time attendant systems, quality control systems, production scheduling systems, etc.), SCM systems (Supply Chain Management systems for advanced planning and scheduling capabilities), ERP systems (Managing transactions such as procurement, inventory transactions, returns, etc.) and PDM Systems (Product Data Management). The major business processes involved include:



- Spare Parts Demand Planning –Forecasting part demand by location, inventory stocking hierarchy and by time period based on historical consumption patterns and probabilistic models based on condition based monitoring.
- Spare Parts Replenishment Planning – Planning for spares replenishment based on ordering parameters like lead time, order lot size, forecasted consumption (schedule based as in the case of routine periodic changes for items such as filters, seals and bearings; consumption based as in the case of breakdowns and preventive activities; equipment life cycle based etc.), substitution rules, safety stock requirements (statistical safety stock or rule based safety stock) and the possible sources of supply (OEM spare vs. indigenous supplier).
- Spare Parts Procurement – Procurement of spares from the vendors might include vendor development and vendor rating processes apart from the standard purchase order process.
- Spare Parts Inventory management And Deployment – Typically, the information on spares across a factory or group of factories on availability and stocking location is not visible at an aggregated level causing expeditions where stock transfers could have sufficed. Hence it becomes important to manage spare parts inventory across the service network and provide inventory visibility. The process would also include allocation rules

on how inventory needs to be deployed across the network. This could be based off inventory models such as ABC (Cost based), FSN (Movement based) and VED (Criticality based) or a mix of the three. Safety stock requirements at every location could be based off service levels and inventory analysis models as mentioned above.

- Spare Parts Design And Development – A regular feature of spare parts planning is the ability to achieve quick turnaround leading to development of local alternative suppliers. The design and development of parts becomes a vital requirement. Also, any substitution and modifications on equipment parts needs to be captured both on the service history as well as in the design records.
- Returns Management – The process of receiving and accounting for part returns as well as carrying out repair activities and making the part serviceable. Steps involved could include return receipt, return categorization, return accounting, return processing and service closure.
- Infrastructure Systems – This would include systems such as decision support and business analytics, knowledge management and event management. As an illustration, a decision support system could help in analysis of service history to predict equipment failure as well as predict usage rates of spares across the equipment life cycle. Causal analysis and failure analysis would need to identify and disaggregate the effect of various causal factors that may result in a demand for a spare part. For example, certain demand could be because of part failure whereas other demand could be because of a meshing part failure. Hence, arriving at the aggregation level across parts at which demand needs to be forecast becomes fairly critical.

Complexities In Spare Parts Management

The processes described under Spare Parts Management have complexities that make automation and information management critical to their successful execution. To illustrate, let's examine the enormity of data and the complexity of analysis involved in typical decisions such as:

- **How do we predict demand?**
- Demand of spares cannot be easily gauged because the consumption of spares can be event based or probabilistic in nature. The events themselves can be scheduled or planned events or unplanned. Scheduled maintenance, capital overhauls etc., would fall in the first category whereas breakdowns would be in the second category. Historical records on breakdowns could be inaccurate particularly due to lack of system support in this area. The intermittent nature of spare part demand due to breakdowns makes it impossible to apply conventional time series based algorithms. The choice of the right model becomes vital and that would depend on the usage rates and the usage patterns.
- **What inventory do we carry and where? How do we allocate inventory in a multi – echelon logistics network?**
- The problem statement here would vary depending on the organization. For a typical manufacturing plant, the inventory is held at two levels – at a shop level and at the plant level. For a service organization, inventory holding is done as a part of a multi-echelon service network – this could range from a centralized national depot to regional depots and down to city depots as well as mobile inventory in the form of service trucks that service installations along specific routes. Hence the problem statement here is larger and

more complex and includes elements of route optimization, network optimization (how many echelons do we keep?), etc. The allocation of inventory in such a case becomes a function of the geography, operational conditions (An Air Conditioning system in a very hot climate needs more service attention than one in moderate climates), and service response needs, etc. Arriving at a good basis for allocations and incorporating that through a system can substantially improve service levels and response time.

- **How do we manage parts substitution and alternates?**
- Spare parts can exhibit characteristics such as substitution and the problem of managing substitution is probably most complex when it comes to service maintenance. The need to keep an equipment running can often lead to bad choices and decisions that can significantly impact future service needs. A substitution could be an exact substitution meaning there is no change in the equipment specs apart from the part itself. On the other hand, it could be a case of accommodating some changes such as re-boring to enlarge the bearing seat and use a larger bearing. In which case the original spare becomes defunct and a new spare needs to be set-up. Setting up substitution/ alternates relationships from a forecasting perspective could however help part rationalization and help manage the large number of stock units. Equipment that is no longer manufactured and whose spares are difficult to get could be ideal candidates for setting up alternates. In which case, the decision variable really is twofold – “where use” and “when use”.

- **When do we phase out a part from the inventory portfolio?**
- Often we see equipment being operated long after they should have been de-activated – there normally is a business need for that. The spare parts management in this case needs to account for the life cycle stage and look at the economics of ordering spares. The decision here could be to deplete and exhaust spare inventory or carry it as before. There could be cases of identifying alternates from other operational equipment and using that for repairs rather than carry original spares. The equipment history and the operating condition as well as the “Need factor” for the equipment can be the decision criteria on which decisions to obsolete can be based.

- **How do we tackle variability in procurement?**
- The inventory carried is a function of the demand uncertainty and the uncertainty around the procurement lead-time. Imported equipment need original spares that are typically buffered to guard against the longer procurement lead-time. Considerations like economic order quantity, usable shelf life, price discounts etc. would also need to be taken into account.

- **How do we manage shifting inventory?**
- The equipment and spares may be moved from location to location in a service network – this would call for dynamic updation of the location. Likewise, date sensitive spares would need recording of the “Use date” against actual consumption vis-à-vis the “procurement date” to ascertain the correct usable life of the spares.

Best Practices In Spare Parts Management

Given the complexities and the growing criticality of the spare parts management function, it is essential that the spare parts management solution meet the critical requirements during any implementation. Some of these are:

- ✓ **Multi-model based inventory management** – ability to plan for parts based on a variety of models such as criticality models, cost models or movement models or a mix of various models.
- ✓ **Optimization models for multi-echelon inventory** to deploy inventory at various locations based on need, criticality, service response, etc.
- ✓ **Capabilities for operational as well as tactical planning** – integration with production and operational plans to optimize equipment availability; optimize the spare storage with respect to usable life as well as storage space, etc.
- ✓ **A variety of forecasting algorithms** that can meet different kinds of demand profiles such as intermittent demand models, attribute based demand models, etc.
- ✓ **Ability to handle part alternates and substitution** – ability to capture substitution relationships at the planning level as well as incorporate substitution logic during service execution.
- ✓ **Dynamic updation of part and location** – ability to dynamically update part availability due to location transfers.
- ✓ Handle **spare part expiry** and help maximize usable life.
- ✓ Ability to handle **supercession and obsolescence**.
- ✓ **Ability to track service levels** and parts consumption and to dynamically update the plans based on current patterns.
- ✓ Ability to do **“What If” analysis based on service levels** for the purpose of inventory planning.
- ✓ **Integration with PDM applications** for accessing part design data and the ability to provide design changes and part changes based on repair and part substitution.
- ✓ **Ability to do cycle counts** and provide a variety of models for setting up cycle counts based on parts consumption, parts value, etc.
- ✓ Ability to **attach part serial numbers for the purpose of tracking** – across various stages such as stocking, consumption for a equipment repair, parts repair, parts return, etc.
- ✓ Use of **performance metrics** such as MTTR, MTTF, Unplanned Maintenance Downtime % and % service costs to monitor the efficiency of the maintenance and service processes.²

Other best practices that have an enterprise scope could include:

- ✓ Production Schedules to include the preventive maintenance program.
- ✓ Joint Operations and Maintenance Planning
- ✓ Single ownership for operations and maintenance.

² MTTR - Mean time to repair equipment and facilities for a defined unit of measure like the number of hours operated, number of batch runs, etc.

MTTF - The average time interval between failures for repairable equipment and facilities for a defined unit of measure like the number of hours operated, number of batch runs, etc.

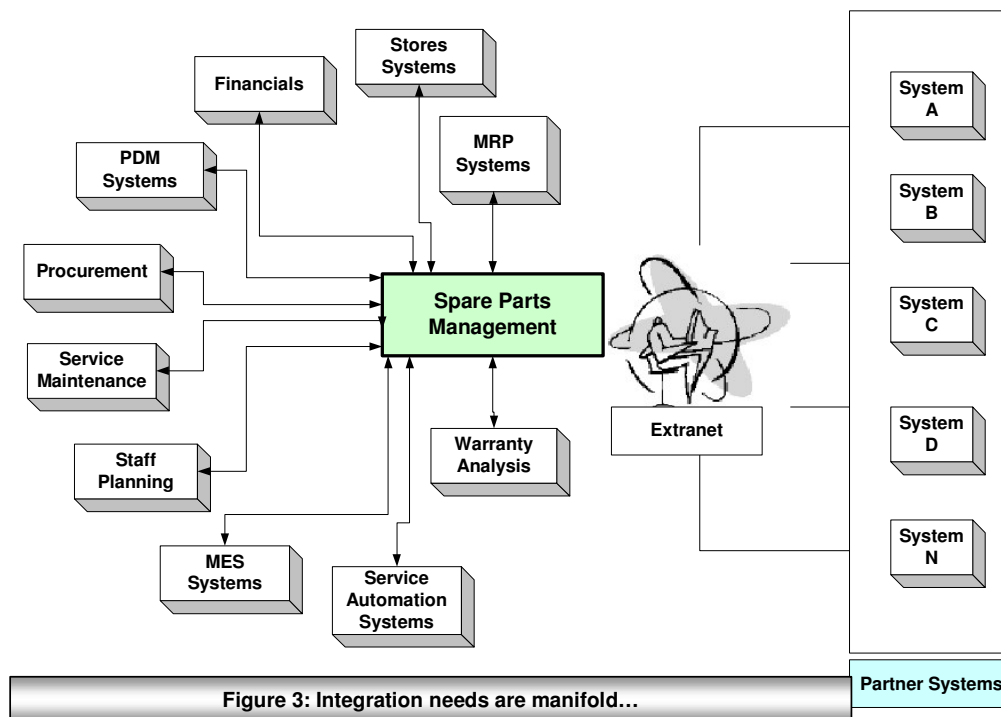
Unplanned Maintenance Downtime % - % of time facilities/ equipment are not available for production due to maintenance and service requirements.

% Service Costs - Equipment/Facility maintenance cost as a % of manufacturing controllable costs.

- ✓ Integrated Total Preventive Maintenance programs – Generation of preventive maintenance schedules that are tightly integrated with MRP systems, Service maintenance records, Inventory systems, Product data management systems, etc.
- ✓ Predictive Maintenance Monitoring & Control - Integrated with various testing systems and capable of storing predictive analysis and observational data;
- ✓ Ability to share best practices or standard service practices across different service groups.

What could be the IT automation approach?

The diagram below shows the application ecosystem and illustrates the extent of interfacing that might be required in automating the Spare Parts function. The example here shows a scenario where the SPM application resides within the enterprise and connects up with various applications to support processes as diverse as procurement and staff scheduling. At the same time, some visibility and collaboration would be required with supplier partner systems such as design, order planning and usage forecasting systems.



Given the perceived gaps in the application vendor space and the high degree of interfacing required with typical legacy applications, it is essential that a structured approach is taken to develop an automation roadmap.

A recommended approach for automation is a 4-step process:

- Do a detailed process study to understand the process requirements and the current application support provided. This would then provide the AS IS and TO BE process models, Gap Analysis (“Process” as well as “Application Support” gaps) results and help decide on the automation path based on the extent and nature of gaps.

- b. Do a package study to determine the relevant vendors in the space – Given that the space is package driven, a package analysis study would help decide if a package path is the optimal one or whether custom development is the way to go. The analysis study would also help select the appropriate vendor based on a variety of factors including functional capability, technological choice, industry presence, financial stability of the vendor and service support capabilities.
- c. Do a due diligence on the selected vendor to demonstrate application capability through a limited “Conference Room Pilot” or likewise. An early demonstration of the package capability to handle business needs can make the implementation and roll out that much easier as well as ensure that the package is the right choice both from a performance and functionality perspective. The same exercise can help firm up the customization/enhancement requirements on other impacted applications.
- d. Develop/Implement the application – Conduct the detailed process study to establish the configuration, workflow and User Interface requirements and implement the same.

To conclude, the application space for automation of the spare parts management function is a developing space. Vendors from the SCM, ERP and the MES worlds are expanding functionality to be able to meet the twin requirements of internal service requirements as well as the external service processes. It therefore becomes vital to conduct a structured exercise to determine the solution that would best fit the needs while leveraging existing infrastructure.

Authors

Sandeep Kumar is a Sr. Consultant with the Domain Competency Group, Infosys Technologies Limited (www.infosys.com). Sandeep has over 9 years of industry and IT consulting experience across industries such as Steel, Earth Moving Equipment and Retail and functions such as Production Planning & Control (PPC), Plant Maintenance, Spare Parts Distribution and Collaborative Planning. Sandeep can be contacted at sandeep_kumar@infosys.com.