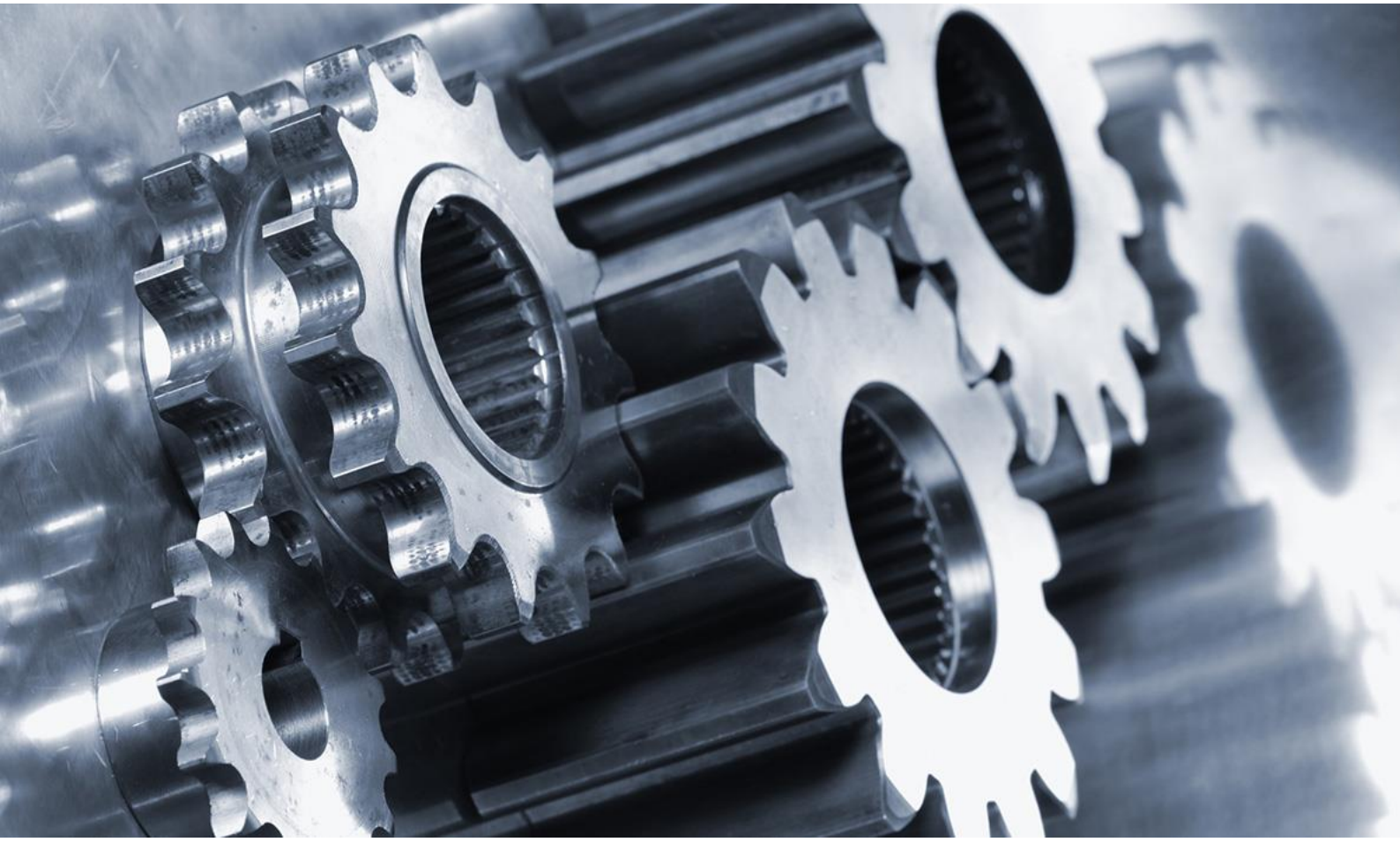
White Paper

MRO Spares Optimisation

Pragmatism by differentiation



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Introduction

Almost all production and service industries have high demands when it comes to uptime of their assets. An asset being down could have disastrous consequences such as lost revenues due to production stagnation or even severe safety issues (e.g. at nuclear power plants). To minimize the downtime of an asset, maintenance must be performed. In order to perform this maintenance it is essential to have the right spare parts on stock.

However, especially for capital intensive assets the costs of being able to maintain these assets regularly and properly could get high. Think of inventory holding costs associated with the working capital of spare parts but also operational costs of transport, warehousing, and transactional costs at the purchase department.

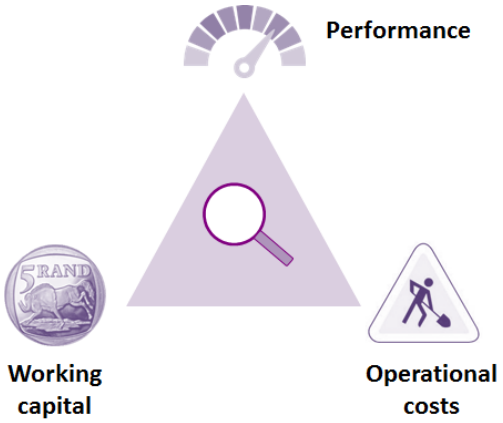


Figure 1. Spare Parts Management: balancing performance, working capital, and operational costs

Today, more and more companies recognize this trade-off of uptime and costs but struggle with the strategy to imbed it in the organization. The root causes are divers but the main drivers we see are a lack of spare parts expertise and the inventory management department not being recognized as such, but also not having a proper IT system in place to cope with the characteristics of spare parts and asset management in general.

The goal of this whitepaper is to provide practical thoughts and concepts for an effective spare parts management organization and processes. After illustrating the unstructured world of spare parts management challenges, we provide an effective concept to create structure and focus by applying different strategies on different sub assortments. Thereafter we come up with practical and specific solutions to solve the most common issues in practice as mentioned before. We conclude with recommendations.

1 Spare parts: the main challenges

One could say that spare parts management is just another term for supply chain management which could be seen in regular retail industries. However in spare parts management there is a set of characteristics or even challenges we have to take into account if we want to get value out of it.

This picture is a simplified representation of the spare parts world. By means of this picture we will outline a number of specific challenges.

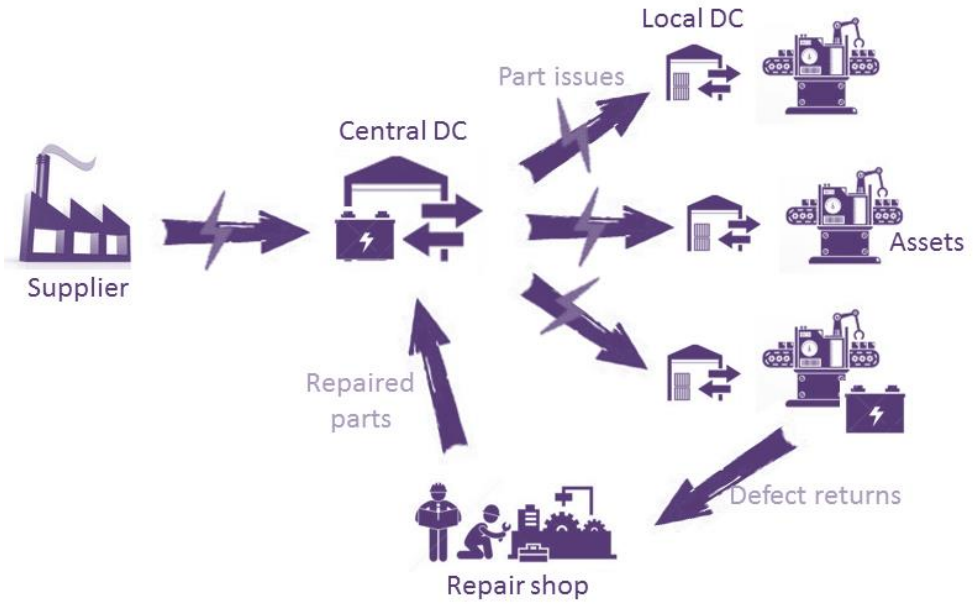


Figure 2. Representation of the spare parts world

1.1 (Un)predictability of demand

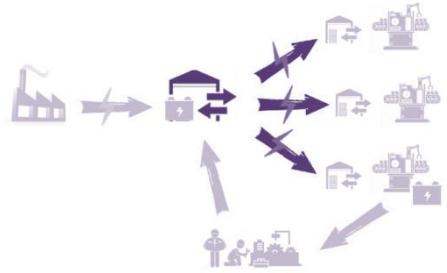


Figure 3. (Un)predictability of demand

The type of maintenance drives the type of demand of spare parts. Preventive maintenance is typically planned in advance. As a result the demand of the spare parts used for this preventive maintenance could be planned or predicted very well. On the other hand in case of a breakdown (corrective maintenance) a specific spare part is needed on a very short notice which could not be foreseen beforehand. The demand could not be planned.

We distinguish between four types of maintenance: preventive maintenance, modifications, corrective maintenance, and component maintenance. Each type of maintenance creates demand for spare parts. However the predictability of this demand differs between each type of maintenance.

Type of maintenance	Demand predictability	Remarks
Preventive maintenance	+/-	Maintenance could be planned in advance but after inspection some additional failures could be discovered. To a certain extent demand is predictable.
Modifications	++	When planned properly demand of spare parts is 100% certain. Spare part demand predictability is very high.
Corrective maintenance	-	Maintenance is not planned. Demand of a spare part is highly unpredictable.
Rotable maintenance	+/-	A rotable is replaced from the asset and repaired separately. The repair could be planned in many occasions but the actual spare parts requirements are not always predictable.

Table 1. Overview of demand predictability for different types of maintenance

Intuitively planned demand of spare parts is preferred over unplanned demand from a logistics point of view. Supply and demand could be aligned more easily as a result of which less inventory is needed. Moreover the fact that the supply chain becomes more lean means that operational waste is minimized in terms of time and costs.

The level of planned demand could be increased by incorporating engineering information in the spare parts planning. This could be achieved by connecting spares parts and components to the asset bill of material, by connecting the replaced spares to work orders tasks, or by deriving inventory levels from the probability that a specific spare part caused an asset failure (x% lists).

Another trend we see today is Condition Based Maintenance. This concept measures the condition of components in order to technically predict the failure of that component. When this information properly boils down into the spare parts planning the demand of spare parts becomes more planned with all advantages as mentioned.

1.2 (Un)predictability of supply

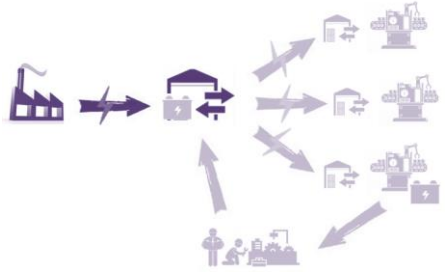


Figure 4. (Un)predictability of supply

Inventory models typically use supply parameters as input, e.g. minimal order quantities, rounding quantities, and a planned lead time. In many organizations these parameters are considered deterministic whereas in practice supplier lead times for instance could fluctuate a lot.

We describe four possible causes for this fluctuation.

- No framework contract in place
  In almost all framework contracts with suppliers lead times are agreed upon for a fixed period. Main advantage is that the buyer does not have to reconsider supply sources which shortens the lead time dramatically.

- Supplier lead time depends on production schedule
  Depending on the type of component, some suppliers only produce after receiving an actual purchase order (deliver to order). In extreme occasions suppliers do not even start production when the production batch is too small because set up costs are too high. Supplier lead times could easily exceed a year.

- Lead time depends on purchase quantity
  Suppliers could decide to keep stock available for expected purchase orders. However, when purchase quantities or lot sizes vary a lot the supplier will not always take on the job immediately. The supplier will treat peak demands separately by producing them to order.

- Obsolescence
  At the end of an asset's life cycle the risk of obsolete spare parts increases. This could result in a situation where that part could not be supplied anymore. In many cases this information does not end up in logistics departments as a result of which complete systems must be modified or replaced.

1.3 Repairable parts

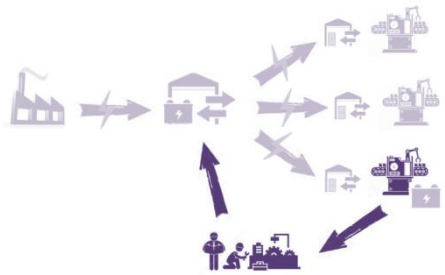


Figure 5. Repairable parts

An important difference of spare parts management in comparison with classical supply chain management in production environments is the possibility to repair spare parts. This creates an extra flow of supply to take into account. A few challenges come into play:

- Repair lead times must be incorporated
  When a defect repairable component is replaced by a serviceable component the defect is sent to a repair shop for repair. Depending on the agreements between the repair shop and the logistics organization a certain repair lead time is agreed upon. Typically this repair lead time will be shorter than the (new buy) lead time when purchasing that part in brand new condition. This results on a lower inventory level of serviceable parts.

- Scrap rate must be monitored
  When a repairable part gets defect, it is diagnosed after which a technical and economic decision is made to repair the part or not. When the part will not be repaired the part is scrapped. In order to fulfil demands in the future the so called turnaround stock must be replenished with serviceable parts. A high scrap rate therefore means many purchases of new parts with corresponding long lead times.

- Unserviceable parts must be collected
  A repair shop can only repair parts when the unserviceable part is collected. In many organizations this collecting process does not run smoothly. There is no incentive for a mechanic to do so, their focus is on getting the asset up and running again. Besides, this part of the process is often not depicted in the IT system resulting in a

lack of control. Worst case scenario is that these parts get lost and new parts have to be purchased.

- Adequate pricing is difficult
  The actual repair or revise activities strongly depend on the failure of that component. Repair could mean replacing a filter or a complete overhaul of the component. This results in fluctuating repair costs. When using a "repair by replacement strategy" an anonymous part (already repaired once) is taken from stock and mounted into the asset. The original repair costs of that particular part cannot automatically be assigned to the corresponding asset. There are options to cope with these pricing challenges but at least frequent repair cost analyses and communication between the logistics and financial department is key.

1.4 Criticality

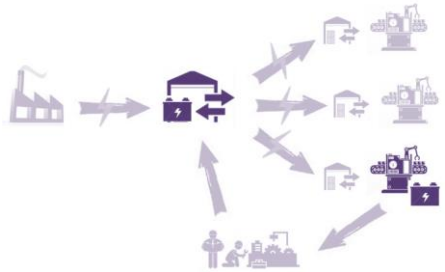


Figure 6. Criticality

The main goal in production environments is to minimize production down time. A breakdown of an asset in the production line does not necessarily create down time in production. E.g.: One could decide to continue processing without having the cooling system working temporarily. The same rule holds for the breakdown of a spare part or component in an asset. The corresponding asset could still function properly without the functioning of that particular component.

Spare parts management deals with the distinction between critical and non-critical items. Critical items are items that directly create asset downtime or even production down time[1]. Typically critical items are expensive, have long lead times, but will not fail often. These expensive slow movers are most risky in terms of downtime but at the same time most difficult to handle from an inventory management point of view. On the other hand non-critical items are issued a lot, are cheap and have lead times of a few days. Taking this distinction into account means that we have to apply different strategies on both categories.

1.5 Multiple sites

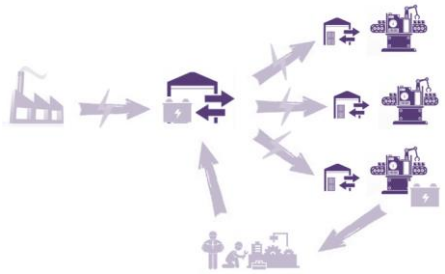


Figure 7. Multiple sites

Especially large maintenance/production organizations have a network of sites. The installed base of assets as well as the inventory of spare parts is scattered over multiple

[1] Production down time obviously only holds for production environments. Analogously, in service industries one could imagine having a critical number of assets to deliver an appropriate level of service to the client.

sites possible in a certain echelon structure. Not every site is equal in terms of size, turnover, productivity so inventories must be scaled over the network accordingly.

In practice we see that these larger organizations have a substantial level of commonality in their spare parts over the different sites, i.e. a particular spare part could be stocked at multiple sites. Managing every site independently could potentially cause overstock in the network. Spare parts pooling is an ideal solution.

This concept holds that the network is considered as one inventory point as a result of which all uncertainties in the supply chain are levelled out and the integral inventory level will drop. The network as a whole always has sufficient inventory to fulfil the demand, the only challenge is: is the spare part on the right location? The downside of this concept is the need to setup a coordination mechanism, e.g. to determine whether it is necessary to reallocate stock.

2 Spare parts differentiation

In order to capture the majority of the spare parts characteristics that *really* impact the triangle a certain differentiation is required. Recall, the main goal in Spare Parts Management should be finding a proper balance between performance (availability), working capital, and operational costs. Since not all organisations and their challenges are identical, finding this balance is not an "off the shelf" method. Different Spare Parts Management strategies have different focuses on different sub assortments of parts, but also on different spare parts characteristics and spare parts supply chain processes.

2.1 Differentiating based on price and demand frequency

Practice shows that price and demand frequency are adequate discriminators for classifying a spare parts differentiation. Below we will make this statement more intuitive.

In the remainder of this section we outline each strategy in terms of inventory policy, managerial focus, and competences.

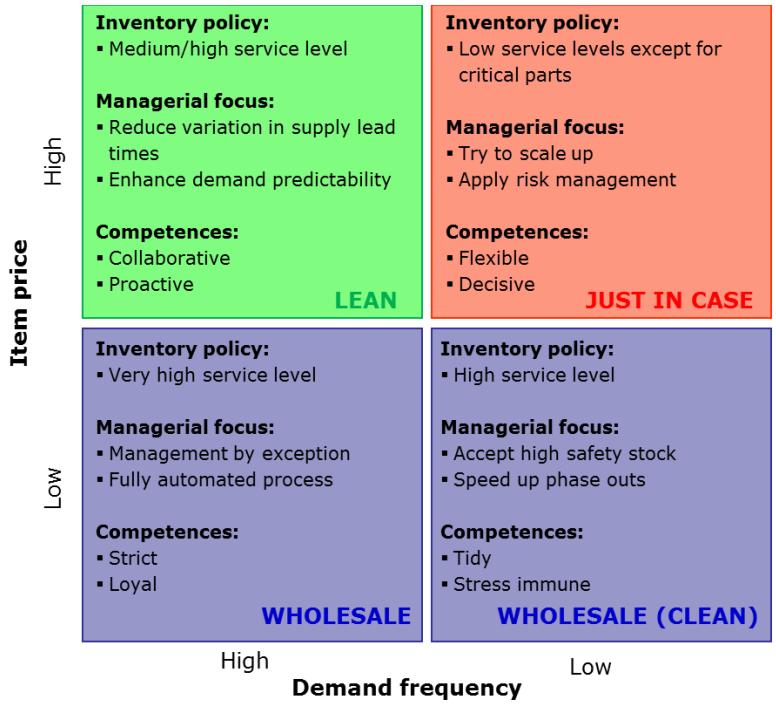
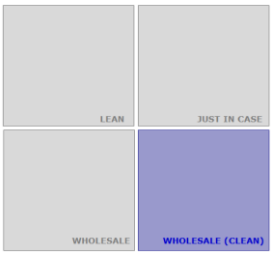
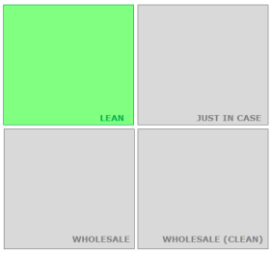


Figure 8. Differentiated spare parts management strategies

Wholesale	Wholesale (clean)	Lean	Just in case
			
This strategy focuses on **minimizing interference** of planners. We are dealing with fast movers so **statistics work well** as a result of which standard ERP systems can handle these neat demand patterns properly. The forecasting and replenishment process should be **automatized maximally** and human interference only occurs when predefined review criteria are not met. We call this management by exception. Moreover, set **service levels should be very high** (> 99%) since the associated inventory has little financial consequences because of the low item price. This low price also means that we **minimize the number of replenishments**. If we order parts we cover a demand of 6-12 months meaning that the average inventory is relatively high. This could easily be accepted as item prices and therefore inventory costs are low. Finally as we are maximizing the level of automation the people should not interfere with the system. Spare parts planners who think that they still can add value to the planning decision are counterproductive. Typically a **strict organization** thrives well here as they are aware of the clear principles of the management by exception concept.	In comparison with the wholesale sub assortment these parts only differ in demand frequency. Because of the low price and low demand frequency this group of parts is **often forgotten**. These cheap slow movers do **not affect the overall availability much and neither the inventory value**. However, because of this low urgency of inventory control there is a **high risk** of parts **catching dust** in the warehouse. This takes up unnecessary **space** in the warehouse. Furthermore parts exceed **shelf life** and need to be thrown away. Strategy must be **cleaning periodically**. Parts should **be phased out rapidly** and obsolete parts must be **disposed of**. Periodically the assortment is kept within boundaries and **clean**. Full time focus is not necessary as the key performance indicators are not affected dramatically.	In the Lean assortment, i.e. expensive fast movers, one should aim for **harmonizing supply and demand**. Volumes are high as a result of which every fluctuation in supply or demand is translated in high inventory value. Looking outside the box is key. Demand fluctuation must be kept to a minimum by **making use of engineering information**. This technical information can be used to **make demand deterministic** and to arrange close to just in time purchase orders for this part of demand. Inventories are kept to a minimum and only correspond with the stochastic part of the demand. On the other hand one should **collaborate with suppliers**. Fluctuations in supply lead times can be minimized by setting up a **Collaborative Planning, Forecasting, and Replenishment (CPFR)** process with suppliers. By **sharing demand forecasts** suppliers can level their production and are able to deliver in **shorter supply lead times** creating a **win-win** situation for both supply chain parties. A clear success factor is the **willingness to cooperate** and the competence of being flexible, entrepreneurial, and **proactive**. Such interventions are challenging but often **most rewarding** when it comes to inventory reduction!	The key element of the Just in case assortment is **risk management**. Parts are expensive but statistics will not work either. Often **asset critical parts** have these characteristics which makes inventory decision making even more challenging. A thorough and frequent **consultation structure with all stakeholders** or even **self-regulating teams** are essential to properly assess risks. To make sure all available information is used to assess the risks typically engineering, purchasing, logistics, production/maintenance, and finance should **periodically join** to decide on these Just in case matters. Moreover, one should seek for **upscaling possibilities**. One option is a **pooling mechanism** over different sites, with other companies or even with competitors[2]. Often it is a decision to have 1 part on stock or no stock at all. With this pooling mechanism this spare part could be **shared by multiple parties** making the business case of keeping it on stock a lot easier.

[2] As long as having inventory is not the core of business companies could collaborate on these non-core activities and compete on selling their finished products or services, also known as coopetition.

2.2 Practical examples

2.2.1 Wholesale

Figure 9. Wholesale: screws and bolts

Typical Wholesale parts for maintenance are screws and bolts. These parts are issued a lot and are extremely cheap. When having the inventory control in-house set service levels should be over 99,5% and replenishment takes place once a year. Inventories are high but human interference is negligible. One could even decide to outsource the inventory control by means of a vendor managed inventory principle.

2.2.2 Wholesale (clean)

Figure 10. Wholesale (clean): gaskets

Gaskets are used to seal surfaces to prevent leaking or to keep pressure. Gaskets are relatively cheap and are not replaced as often as screws and bolts. But on the same time these are often perishable goods which means that the inventory control must be aligned with the limited shelf life. In order to minimize obsolescence the inventories must be monitored and cleaned periodically.

2.2.3 Lean

Figure 11. Lean: wheel tyres

In the rail industry wheel tyres are critical for the uptime of trains and need to be replaced when technical norms are exceeded. The production process is complex meaning that supplier lead times can be long and unsure. When keeping inventory to keep up with this supply gets too expensive one could set up an active forecast and delivery process. Demand forecasts are shared and supplier lead times decrease. Results in the European rail industry show that inventories can be reduced with 50% providing a clear willingness to cooperate.

2.2.4 Just in case

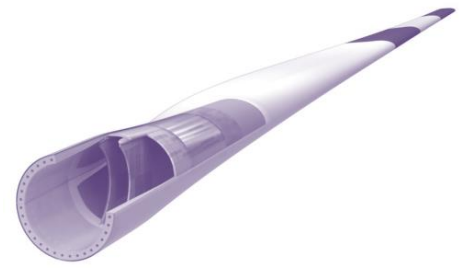


Figure 12. Just in case: wind mill rotor blades

Insurance items are components that are highly critical for the uptime of an asset but will not fail theoretically. However to deal with the worst case scenario many companies choose to pay the "insurance premium" by keeping at least one spare part on stock. This is also the case for wind mill rotor blades.

3 Solutions for practical challenges

Despite the fact that these concepts might sound logical many companies are not able to implement and maintain these strategy concepts within their organizations. We encounter various reasons for this of which we discuss four of them. We also provide a practical comprehensive solution for these challenges.

3.1 Organization

Nowadays we often see a clear demarcation between the maintenance and logistics department of organizations. Given this demarcation the role of logistics is inferior to the role of maintenance while their decisions have a great impact on the performance of the assets that are maintained.

Differentiated spare parts management drives collaboration between these two. Maintenance does not want to be involved in the wholesale assortment: "logistics, just fix it!". But when it comes to expensive critical parts the focus should be on making use of technical information. Logistics will need maintenance in order to make a proper spare parts planning decision. In order to make this differentiated strategy work collaboration is a success factor.

Moreover we encounter a relatively low level of education and specialised knowledge in organizations. Without a proper and practical education companies cannot expect that employees completely understand the differentiated spare parts management principles. Besides it gets very complicated for them to understand the outcomes of all corresponding spare parts models. Some organizations choose or are forced to maintain the old way of working but simultaneously deny the real characteristics that play a role in spare parts management.

In practice the following interventions appear to be effective:

- A series of practical spare parts management training sessions aiming on the application of scientific forecasting and inventory management principles in their day to day work.
- Adding one or more young well educated professionals to the spare parts planning department. These people have the ability to think in concepts and to absorb and disseminate these differentiated spare parts management strategies in the organization.

3.2 Data integrity

A typical Dutch saying goes: "meten is weten", which basically means measuring is knowing. Only by measuring your performance you are able to improve. However, a big challenge is to measure the right things and to define the right measures. A big success factor for properly measuring the performance is data integrity.

One could have a fairly advanced system with the most advanced models but when your data is corrupt the output is worthless. Rubbish in is rubbish out!

Before even start planning and measuring one should conduct a thorough data cleaning process. This involves all kinds of data elements, from supplier data, spare part master data, technical data, asset data, etc. Moreover the registration of all kinds of transactions could be unreliable as well. There could be peak demands, excessive supplier lead times, high minimum order quantities, etc.

By means of pre-set exceptions rules a vast amount of data issues could be filtered out quickly and be recovered. This recover process speeds up the process massively as a result of which planners can focus on their core activities.

3.3 Plan Do Check Act process

As we stated earlier a maintenance or service organization should always strive for an optimal balance between performance, working capital, and operational costs. In essence, every decision must add value to this balance and if there are hiccups along the way these must be taken care of immediately. In short this is the main thought of a Plan Do Check Act cycle.

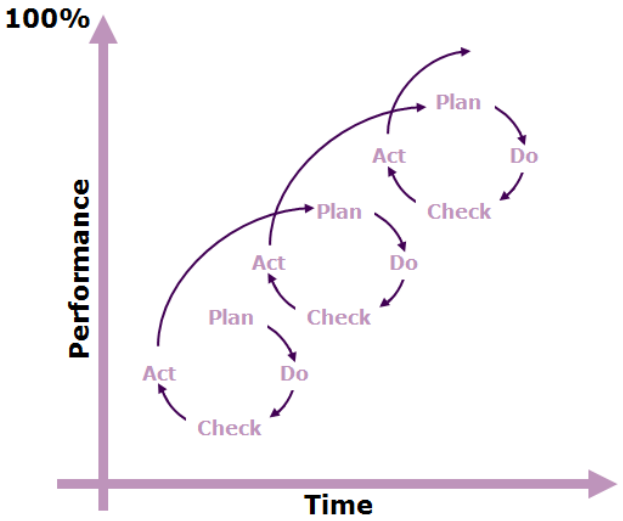


Figure 13. Recurring PDCA loops

In spare parts management this is no different.

> **PLAN:** Bearing the objectives of performance, working capital, and operational costs in mind we set our parameters and we plan our spare parts.
>
> **DO:** Based on these parameters the IT system generates purchase requisitions and spare parts are replenished
>
> **CHECK:** The operational activities continue but meanwhile we check our key performance indicators and check for any negative trends. Maybe one big purchase order sneaked through or we forgot to place an order unfortunately. This could have a huge impact on the KPI's.
>
> **ACT:** If we see some negative trends in our KPI's we must act. This could mean that we solve issues on spare part level but also adjusting inventory control parameters for our predefined sub assortments.

When playing this "game" repeatedly we in fact continuously improve our key performance indicators.

However, this process is often not in place. Many organizations state that they measure KPI's but in most cases these KPI's are not in line with the planning dimensions. In other words, red flags in the KPI measurement could not always be solved by interfering in the spare parts planning parameters resulting in sub optimal solutions.

3.4 ERP functionality

Especially in the last few decades ICT has become increasingly important and even vital to perform business. This also holds for spare parts management. The everlasting challenge is to depict the actual business processes and controls in the ICT system such that efficient and effective decisions are made.

In practice there are several burdens that slow down or even stop organizations for further professionalizing their spare parts management processes.

3.4.1 Inventory models not aligned with spare part characteristics

Talking about spare parts many links could be made with "regular" supply chain management and inventory management. This might be true for 50-60% of the processes but there are some essential differences on the edges.

- In spare parts management we not only handle consumable goods that are issues but also repairable items that come back unserviceable and can be repaired. These principles are not covered in regular inventory models.
- Moreover, demand forecasting techniques generally look at "neat" demand patterns but are not interested in so called slow movers. Fact of life is that typically 60-80% of spare parts are slow moving.

3.4.2 Standardized set up of ERP functionality

ERP systems originally are developed to meet the need of having an integral system for production based organizations. From a logistics point of view this means that ERP systems take the sales forecast of finished goods as a starting point and then calculate the need for spare parts by means of a predefined bill of material and deterministic supplier lead times.

However, in spare parts management some basic principles do not match with the principles of current ERP systems of which a few we already mentioned:

- Standard ERP systems cannot handle repairable items
- Standard ERP systems cannot properly forecast slow moving items
- Standard ERP systems cannot distinguish between planned and unplanned demand on spares level
- Standard ERP systems often calculate a theoretical service level which does not match with the actual service level that is experienced by the maintenance department.

Of course, there are organizations who acknowledge these gaps and try to customize the system in order to meet the actual spare parts characteristics. However, in practice there may be other cheaper options to fill these gaps more effectively by means of a dedicated spare parts planning system.

3.5 Spare parts management as a comprehensive solution

To overcome the aforementioned challenges outsourcing of critical elements in spare parts planning could be beneficial. In spare parts planning we distinguish three levels:

- **The strategic level** where the framework for decisions is set (e.g.: How does the maintenance strategy look like? What is the usage profile? Do we outsource maintenance? What is the procurement strategy?);
- **The tactical level** where inventory planning parameters are determined (e.g. service levels, spare part lot sizes, and safety stocks);
- **The operational level** where the execution happens (e.g. creating purchase orders and expediting towards suppliers).

Typically, the tactical level is the most complex layer because here specific forecasting techniques and spare parts inventory models are used. This is also the layer that generally lacks sufficient expertise and ICT support. With "Planning Services" this tactical spare parts planning is outsourced.

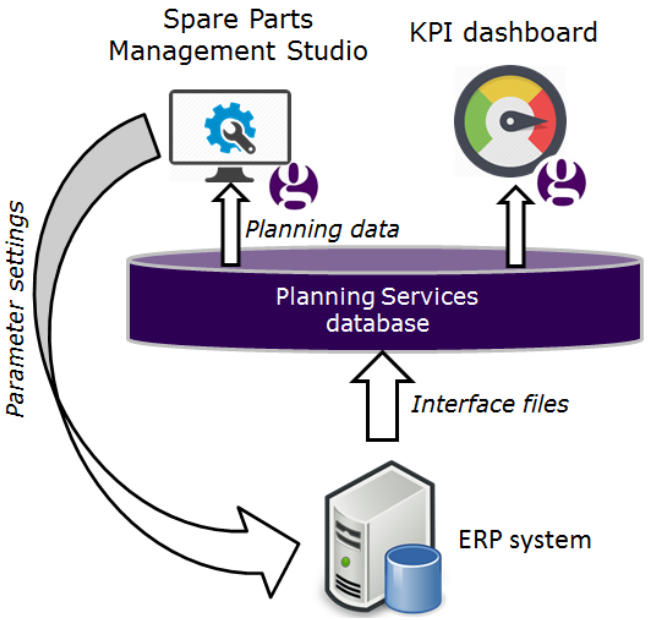


Figure 14. Planning Services: outsourced spare parts planning and monitoring

PLAN Periodically master data concerning purchase orders, demand issues, and general parts information are retrieved from the ERP system of the client and collected in a database. An advanced spare parts planning system calculates inventory control parameters such as reorder points and lot sizes based on a multi segment classification, in line with the spare parts strategies as outlined in section 2.

DO These inventory control parameters are returned to the ERP system where the operational planner will do his/her periodic replenishment run.

CHECK The backbone of this spare parts planning system is the multi segment classification which is used to again optimize the balance between performance (availability), working capital, and operational costs. However, in practice other elements may play a role resulting in a misfit between forecast and realizations. Therefore the key performance indicators are monitored in a KPI dashboard. Trends are tracked and possible red flags are immediately visible.

ACT By means of drilldowns it is possible to assign actions to specific process owners with their own field of responsibility. This could be a maintenance planner, a buyer, a spare parts planner, or the financial controller. If actions need to be taken in the tactical spare parts planning the classification is adjusted or changes are made on part level.

As one can see, Planning Services breaths the Plan Do Check Act concept and enhances continuous improvement.

4 Conclusions and recommendations

During the years we build lots of evidence that with differentiated spare parts management huge benefits can be achieved in performance, working capital, and operational costs. Nevertheless implementing such method is not trivial and should be done with great care.

This whitepaper shows the main steps in the process leading to a successful implementation.

Step 1	**Step 2**	**Step 3**
The first important step is **finding the key issues**. What are the main burdens in the current process? What is the reason of the low performance or high costs? This could be considered from different angles such as the **supply** side, the **demand** side, or **parts characteristics**.	The second step contains the **selection** of the right spare parts management technique. As often a **combination of techniques** is the most effective choice. From an efficiency point of view we recommend controlling the **expensive, more critical spare parts** with a specific spare parts management method. Especially **cheap fast movers** can easily be controlled by forecasting and inventory models in standard ERP systems.	The third step is getting insight into the **practical implications**, i.e. matching the spare parts processes and characteristics with the organization and the supporting ICT system. Regarding the organization there is often a need for an **injection** in spare parts management **knowledge** and **expertise**. Moreover, **communication** between logistics and maintenance departments may be improved. When it comes to ICT add-ons may be considered in case the value add is significant. However, alignment with the **maturity of the organization** should always be bared in mind. Do not buy a Rolls Royce if a Volkswagen will suffice as well.

Finally we provide a number of suggestions when considering initiation of a spare parts project:

- Always start the project with a proper and especially objective problem analysis. Such analysis is the main driver for the potential project and creates a basis for support within the organization.
- Take the project seriously. Assign a dedicated project team that periodically reports to a steering committee or board. Perhaps even more important, inform the complete organization with news letters containing brief progress summaries to manage expectations.
- Create a sufficiently broad project team. All stakeholders needs to be involved actively, especially ICT.
- Realize you are not the first to start a project like this. A quick chat about experience and tips does always help.
- Hiring consultants can be refreshing and can speed up things rapidly. Even considering "external power" means that the matter is not as simple. Although, try to keep control in-house and avoid too much dependency.

5 Accountability

We do not pretend to have written a scientific paper with this whitepaper. The methods and concepts we describe are merely pragmatic guiding solutions of which we experienced they work well in practice.

However, there is a clear scientific basis for the concepts we use. The most interesting scientific references are:

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6 Authors

This white paper is written by Stijn Wouters and Jan Willem Rustenburg. Please contact us if you have any questions and/or want to know more.

"Energetic, passionate, committed to results, an excellent sparring partner with a sense of proportion."

Jan Willem Rustenburg
CEO Gordian
jw.rustenburg@gordian.nl

Area of expertise:

- Service strategic development
- Service logistics
- Spare parts management
- Training
- Management coaching
- Entrepreneurship

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Stijn Wouters
Managing consultant Gordian SA
s.wouters@gordian.nl

Area of expertise:

- Consultancy
- Project management
- Quantitative analysis
- Game theory
- Spare parts management
- Supply chain management

Website: www.gordian.nl

https://www.linkedin.com/company/gordian-logistic-experts

@gordianutrecht

Physical addresses

The Netherlands
Gordian Logistic Experts B.V.
Groenewoudsedijk 63
3528 BG Utrecht

Republic of South Africa
Gordian Logistic Experts SA
Pragma Building, DJ Wood Way
Bellville West, 7530