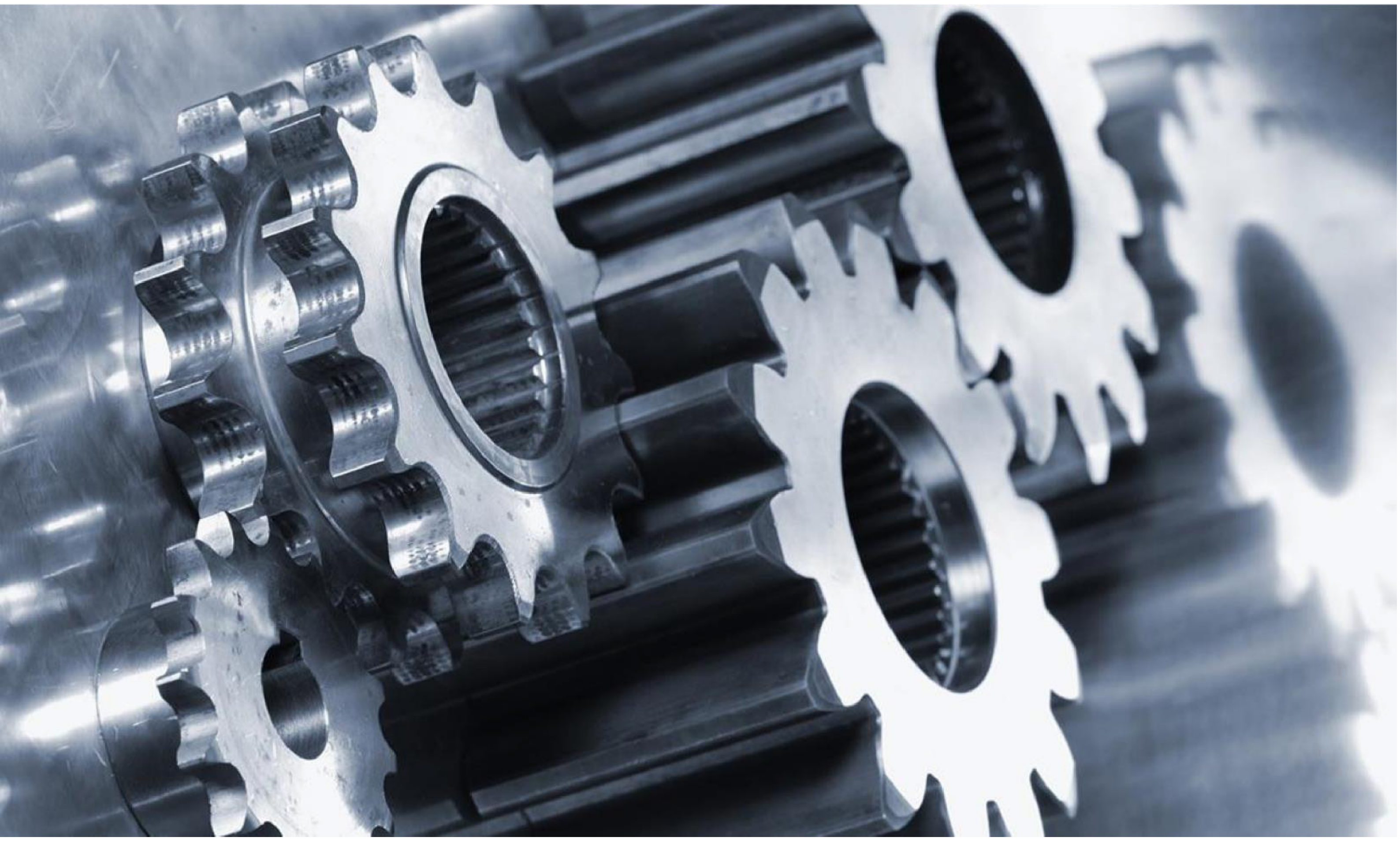
White Paper

Spare Parts Management and Optimisation

Pragmatism by differentiation



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Introduction

Almost all production and service industries have high demands for asset uptime. Asset downtime could have disastrous consequences such as lost revenue due to production stagnation or even severe safety issues (e.g. at nuclear power plants). To minimise the downtime of an asset, maintenance must be performed and this means having the right spare parts in stock.

However, especially for capital intensive assets, regular and proper maintenance can be costly. Think of the stock holding costs associated with the working capital of spare parts, the operational costs of transport and stores, and the transactional costs at the purchase department.

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

Today, more and more companies recognise the importance of achieving a balance between uptime and costs but struggle to embed an appropriate strategy. The reasons for this are diverse but include a lack of spare parts expertise, lack of recognition for the role of the spare parts management department, and the lack of a proper IT system to cope with the characteristics of spare parts and asset management in general.

The goal of this white paper is to provide practical thoughts and concepts for an effective spare parts management organisation and process. After illustrating the unstructured world of spare parts management challenges, we provide an effective concept to create structure and focus by applying different strategies to different sub assortments. Then we propose practical and specific solutions to solve the most common issues. 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 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 extract value from it.

This picture is a simplified representation of the spare parts world and we'll use it to outline these challenges.

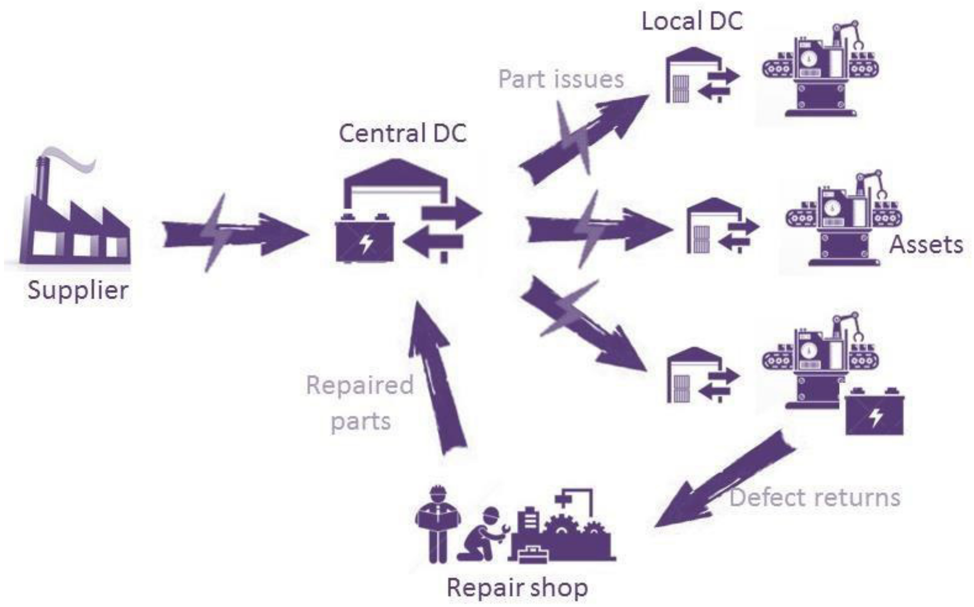

Figure 2. Representation of the spare parts world

1.1 (Un)predictability of demand

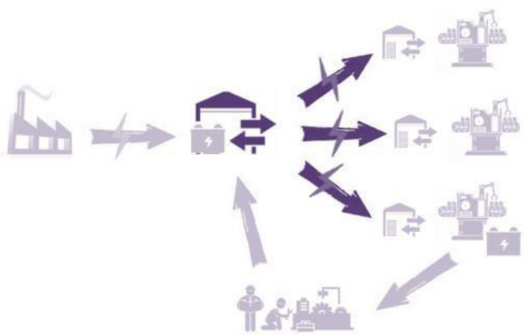

Figure 3. (Un)predictability of demand

We distinguish between four types of maintenance: preventive maintenance, modifications, corrective maintenance, and rotable 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 but the actual spare parts requirement is 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 so that less stock is needed. Moreover the fact that the supply chain becomes leaner means that operational waste is minimised 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 spare parts and components to the asset bill of material, by connecting the replaced spares to work order tasks, or by deriving stock 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

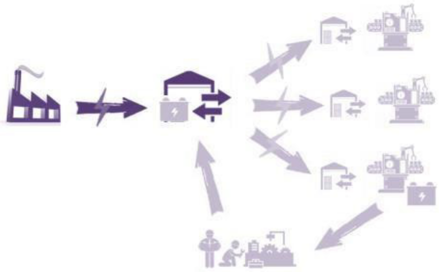

Figure 4. (Un)predictability of supply

Stock calculation models typically use supply parameters as input, e.g. minimal order quantities, rounding quantities, and a planned lead time. In many organisations 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. Not having a framework contract in place means that the buyer has to

reconsider supply sources over and over again. This impacts 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 cases 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 significantly 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 a part cannot be supplied anymore. In many cases this information does not end up in logistics departments so complete systems must be modified or replaced.

1.3 Rotables (repairable parts)

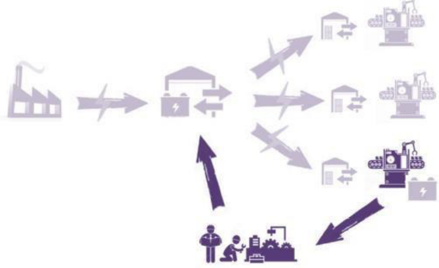

Figure 5. Rotables

Unlike classical supply chain management in production environments, in spare parts management some spare parts can be repaired. This creates an extra flow of supply to take into account. Possible challenges come into play:

- **Repair lead times must be incorporated**
  When a defect rotable is replaced by a serviceable rotable the defect – or unserviceable part - is sent to a repair shop. A certain repair lead time is agreed upon which is typically shorter than the lead time required for purchasing a new part. This results in a lower stock level of serviceable parts.

- **Scrap rate must be monitored**
  A rotable is diagnosed and a technical and economic decision is made to repair the part or not. If the part will not be repaired it 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 organisations this collecting process does not run smoothly. There is no incentive for a mechanic to do the collecting; 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. The worst case scenario is that these parts get lost and new parts have to be purchased.

- **Adequate pricing is difficult**
  The actual repair strongly depends on the failure of that rotable. Repair could mean replacing a filter or a complete overhaul of the rotable. 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 the least, frequent repair cost analyses and communication between the logistics and financial department is key.

1.4 Criticality

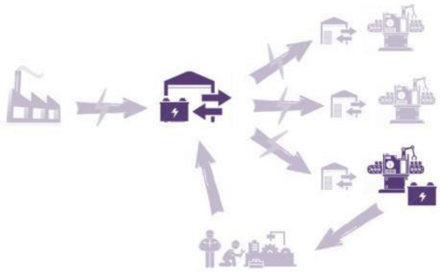

Figure 6. Criticality

The main goal in asset management is to minimise downtime on assets. The breakdown of an asset does not necessarily create downtime, e.g. the company could decide to continue processing without the cooling system working temporarily. The same rule holds for the breakdown of a spare part or component in an asset. The 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 downtime[1]. Typically critical items are expensive and have long lead times, but will not fail often. These expensive slow movers are most risky in terms of downtime and are also most difficult to handle in spare parts management. On the other hand non-critical items are issued frequently, are cheap and have lead times of a few days. This distinction means applying different strategies to both categories.

1.5 Multiple sites

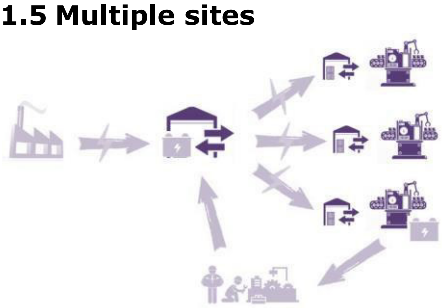

Figure 7. Multiple sites

Large organisations have a network of sites. The installed base of assets and the spare parts of spare parts are scattered over multiple sites, possibly in a certain echelon structure. Not every site is equal in terms of size, turnover and productivity so stocks must be scaled over the network.

[1] Production downtime 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.

In practice we see that these larger organisations 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 stock point as a result of which all uncertainties in the supply chain are levelled out and the integral stock level will drop. The network as a whole always has sufficient stock to fulfil the demand; the only challenge is: is the spare part at the right location? The downside of this concept is the need to set up a coordination mechanism 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 shown in figure 1, a certain differentiation is required. Remember that the main goal in spare parts management should be finding a proper balance between availability, working capital, and operational costs. Since not all organisations and their challenges are identical, finding this balance is not an 'off the shelf' process. 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 stock policy, managerial focus, and competences.

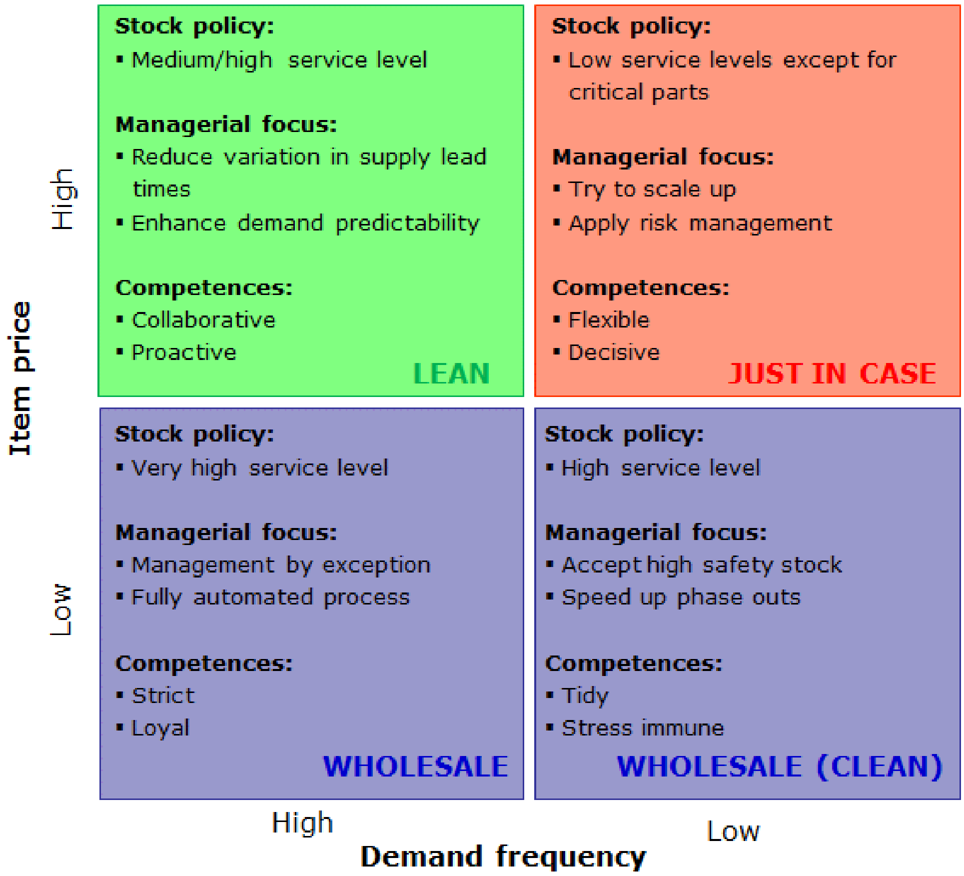

Figure 8. Differentiated spare parts management strategies

Wholesale

This strategy focuses on **minimising 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 **automated 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 stock has few financial consequences because of the low item price. This low price also means that we try to **minimise the number of replenishments**. If we order parts we cover a demand of 6-12 months meaning that the average stock is relatively high. This could easily be accepted as item prices and therefore stock holding costs are low.

Finally, because we are maximising the level of automation, staff should not interfere with the system. Spare parts planners who think that they can still add value to the planning decision are counterproductive. Typically a **strict organisation** thrives well here as they are aware of the clear principles of the management by exception concept.

Wholesale (clean)

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 or the stock value**.

However, because of this low urgency of stock control there is a **high risk** of parts **gathering dust,** taking up unnecessary **space** in the warehouse, and needing to be discarded after exceeding their **shelf life**.

Strategy must be **periodic cleaning**. Parts should **be phased out rapidly** and obsolete parts must be **disposed of**. Creating new parts must be limited, or at least controlled. Full-time focus is not necessary as the key performance indicators are not affected dramatically.

Lean

In the Lean assortment, i.e. expensive fast movers, one should aim for **harmonising supply and demand**. Volumes are high as a result of which every fluctuation in supply or demand is translated in high stock value.

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.

Collaboration with suppliers is important. Fluctuations in supply lead times can be minimised 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 ability to be flexible, entrepreneurial and **proactive**. Such interventions are challenging but often **most rewarding** when it comes to stock reduction!

Just in case

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 stock decision making even more challenging.

A thorough and frequent **consultation structure with all stakeholders** or even **self-regulating teams** is 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 look 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 one part in 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.

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[2] As long as having stock 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 often and are extremely cheap. When the stock control is in-house, target service levels should be over 99.5% and replenishment takes place once a year. Stocks are high but human interference is negligible. The stock control could even be outsourced by means of a vendor managed stock principle.

2.2.2 Wholesale (clean)

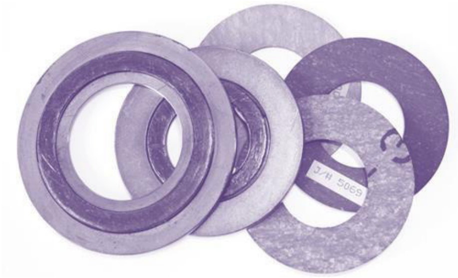

Figure 10. Wholesale (clean): gaskets

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 gaskets can be perishable, so the stock control must be aligned with the limited shelf life. In order to minimise obsolescence the stock 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 uncertain. If keeping stock 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 stocks can be reduced by 50% providing there is a clear willingness to cooperate.

2.2.4 Just in case

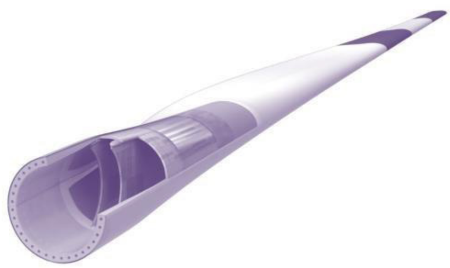

Figure 12. Just in case: windmill rotor blades

Insurance items are components that are highly critical for the uptime of an asset but will theoretically not fail. 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 windmill rotor blades.

3 Solutions for practical challenges

Although these concepts might sound logical, many companies are not able to implement and maintain them. We will discuss four reasons for this and provide a practical comprehensive solution for each one.

3.1 Organisation

Nowadays we often see a clear demarcation between the maintenance and logistics departments of organisations. Given this demarcation the role of logistics is inferior to the role of maintenance yet 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; their mantra is "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 organisations. Without proper and practical education, companies cannot expect employees to completely understand the differentiated spare parts management principles. Besides, it becomes complicated for them to understand the outcomes of all corresponding spare parts models. Some organisations choose to 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 aimed at the application of scientific forecasting and stock control principles in their day-to-day work.
- Adding one or more young well-educated professionals to the spare parts planning department on a tactical level[3]. These people have the ability to think in concepts and to absorb and disseminate these differentiated spare parts management strategies in the organisation.

3.2 Data integrity

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

A company can have a fairly advanced system with the most advanced models but if the data is corrupt the output is worthless. Rubbish in is rubbish out!

Before even starting to plan and measure, a thorough data cleaning process needs to take place. This involves all kinds of data elements from supplier data, spare part master data, technical data, asset data, etc. 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 exception rules a vast amount of data issues could be filtered out quickly and be recovered. This speeds up the process massively, freeing up planners to focus on their core activities.

3.3 Plan Do Check Act process

As we stated earlier a maintenance or service organisation should always strive for an optimal balance between availability, working capital, and operational costs. In essence, every decision must add value to this balance and if there are problems along the way

[3] The meaning and prerequisites for this tactical level in an organisation is explained in section 3.5

these must be taken care of immediately. This is the underlying concept of a Plan Do Check Act cycle.

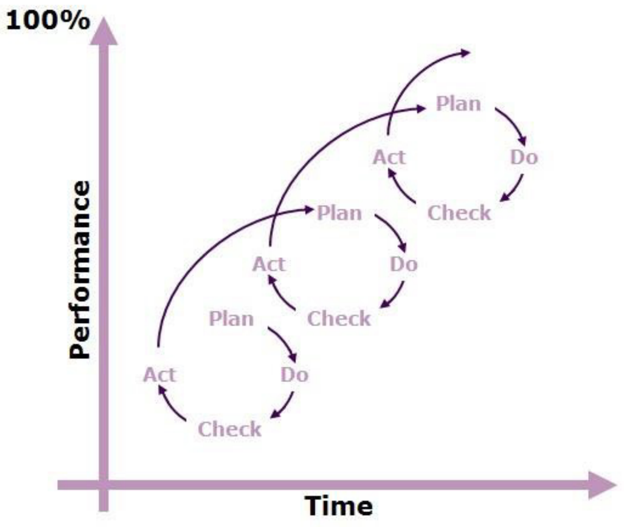

Figure 13. Recurring PDCA loops

In spare parts management this is no different.

PLAN: Bearing in mind the objectives of availability, working capital and operational costs 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 (KPIs) for any negative trends. Maybe one big purchase order sneaked through or we forgot to place an order. This could have a huge impact on the KPIs.

ACT: If we see some negative trends in our KPIs we must act. This could mean that we solve issues on spare part level but also adjust stock control parameters for our predefined sub assortments.

When playing this 'game' repeatedly we in fact continuously improve our KPIs.

However, this process is often not in place. Many organisations state that they measure KPIs but in most cases these KPIs 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 so that efficient and effective decisions are made.

In practice there are several burdens that slow down or even stop organisations from further optimising their spare parts management processes.

3.4.1 Stock calculation models not aligned with spare part characteristics

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

- In spare parts management we not only handle consumable goods but also rotable items that come back unserviceable and can be repaired. These principles are not covered in regular stock calculation models.
- Moreover, demand forecasting techniques generally look at 'neat' demand patterns but do not cover so-called slow movers. The fact is that typically 60-80% of spare parts is slow moving.

3.4.2 Standardised set-up of ERP functionality

ERP systems are developed to meet the need of having an integral system for production based organisations. 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 the principles of current ERP systems, a few of which we have already mentioned:

- Standard ERP systems cannot handle rotable 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 the actual service level that is experienced by the maintenance department.

Of course, there are organisations that acknowledge these gaps and try to customise 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. What does the maintenance strategy look like? What is the usage profile? Do we outsource maintenance? What is the procurement strategy?).
- **The tactical level** where stock 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 stock 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.

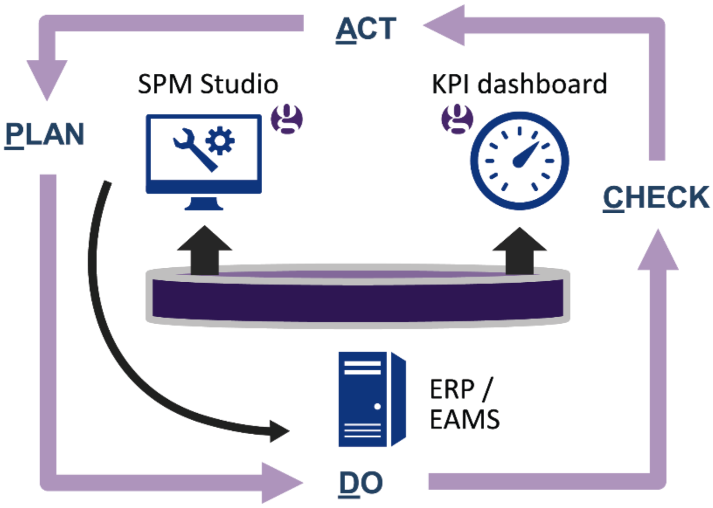

Figure 14. Planning Services: outsourced spare parts planning and monitoring

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 stock 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 stock control parameters are returned to the ERP system where the operational planner will do a periodic replenishment run and creates purchase orders.

CHECK The backbone of this spare parts planning system is the multi segment classification which is used to again optimise the balance between availability, working capital, and operational costs. However, in practice other elements may play a role resulting in a misfit between forecast and realisations. Therefore the KPIs 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 spares level.

4 Conclusions and recommendations

Over the years we've seen evidence to prove that with differentiated spare parts management, huge benefits can be achieved in availability, working capital, and operational costs. Nevertheless implementing such methods is not trivial and should be done with great care.

This white paper 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 problems in the current process? What is the reason for 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. A **combination of techniques** can be 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 stock calculation 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 organisation and the supporting ICT system. Within the organisation there is often a need for an **injection** in spare parts management **knowledge** and **expertise**. Moreover, **communication** between logistics and maintenance departments could be improved. ICT add-ons may be considered in case the value add is significant. However, alignment with the **maturity of the organisation** should always be borne in mind. Do not buy a Rolls Royce if a Volkswagen will suffice.

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. This analysis is the main driver for the potential project and creates a basis for support within the organisation.
- Take the project seriously. Assign a dedicated project team that periodically reports to a steering committee or board. Perhaps even more importantly, inform the entire organisation with newsletters containing brief progress summaries to manage expectations.
- Create a sufficiently broad project team. All stakeholders need to be involved actively, especially ICT.
- Realise you are not the first to start a project like this. A quick chat about experience and tips always helps.
- Hiring consultants can be refreshing and can accelerate progress. Considering 'external power' means that you realise the complexities of your challenges. Where possible though, try to keep control in-house and avoid too much dependency.

5 Accountability

This white paper is not a scientific paper. The methods and concepts we describe are merely pragmatic guiding solutions that in our experience 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.

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- Service strategic development
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- Spare parts management
- Training
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"A clever, analytical and critical team player with a good sense of the bigger picture and structure. Achieving results as a team is what drives me."

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