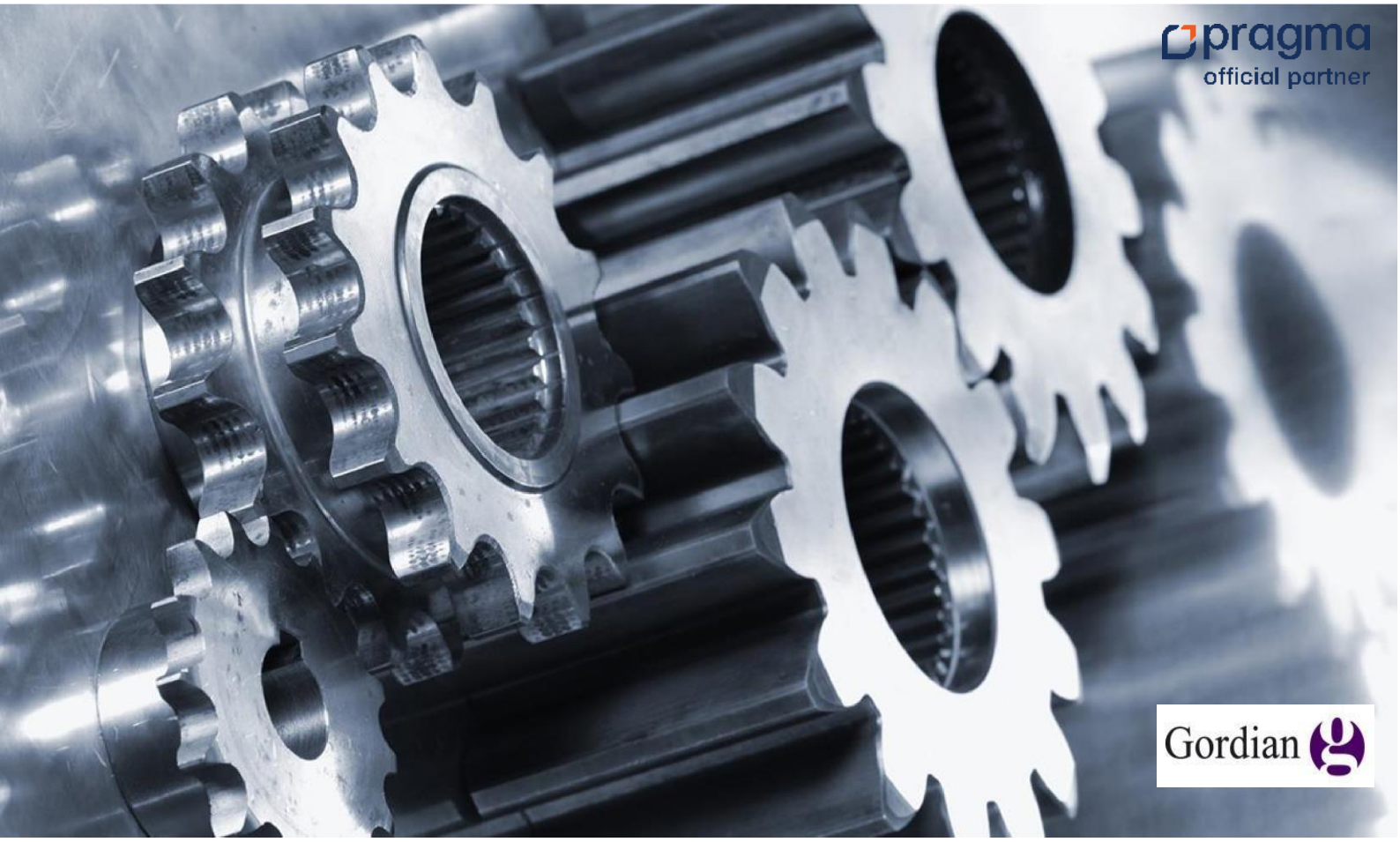
White Paper

The journey to professional Spare Parts Management

How to pass the roadblocks?



1. Introduction

Nowadays many modern manufacturing and service organizations heavily rely on the reliability and the availability of physical assets, such as transport systems, manufacturing systems, etc. Frequent failures or long down times may result in enormous production losses, and ultimately in loss of business.

Effective maintenance policies should prevent unexpected failures or long downtimes. Practice shows that even the most sophisticated maintenance policies cannot prevent long downtimes when having insufficient spare parts on site. For example, preventive maintenance programs often have an inspection-based character. That means – simply stated – that the 'when & what' to inspect is known. However, the potentially resulting repair job including the required spares is not known in advance.

Practice also shows that the spares management is a headache issue for various stakeholders. Without pretending to be complete, the list below provides an impression of the typical current practice:

- The spares availability is too low, affecting the maintenance operations;
- The working capital is too high, putting pressure on the financial situation of the organisation;
- The stores are full of parts that hardly move;
- The procurement department is working overtime due to the vast amount of uncoded and unstructured requests for spares.

Many companies stress the importance of solving the spares issues, yet they struggle to define an effective roadmap that leads to sustainable solutions. This paper describes a generic roadmap that serves as an inspiration for maintenance organizations worldwide and allows companies defining their starting point. Secondly, we deal with the most encountered roadblocks on this journey.

The roadmap is based on the vast experience of Gordian Logistic Experts, both from projects as well as from surveys in several industries. The roadmap is also inspired by the asset management roadmap of Pragma (https://www.pragmaworld.net/integrated-asset-management-a-roadmap/), a trusted partner of Gordian.

2. The roadmap to professional spare parts management

Where to start the roadmap? Well let's start right at the beginning. Imagine a start-up factory. The owners bought the required machines, recruited the personnel and started operating. Smartly enough they acknowledged that maintenance should be done in order to sustain production. Technicians became responsible for that job and the buyers bought the required spares directly at the suppliers. Upon completion of every maintenance job the left over spares are stored somewhere in the production facility. In the beginning stages this works but as time elapses the factory starts to grow. Very soon the owners see that this practice is becoming very messy and unproductive.

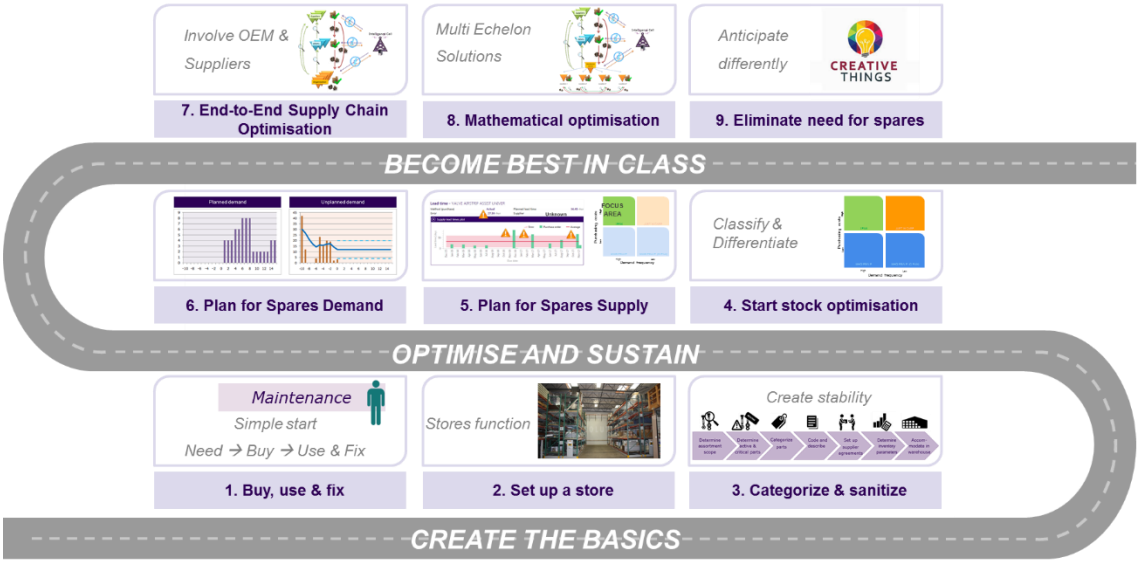
Where to end the roadmap? Let's dream a little. In essence, spares parts are needed to minimize downtime. But suppose we can predict failures using machine learning techniques and we can produce the spares using 3D printing. Why do we need to stock spares in the first place?

Practice shows that some companies are still in the early stages and – albeit in an innovative stadium – a small set of companies is exploring to eliminate the need for spares. The vast majority swims somewhere in between.

Primarily for project management reasons, we break down the roadmap into 3 roads connected by bends:

- Road 1: Create the basics
- Road 2: Optimise and sustain
- Road 3: Become best-in-class

The figure below sketches the overall roadmap.



Finally, we stress the overall broad nature of this paper. Behind each sub step of the roadmap, there is a world of complexity that deserves significant specific attention.

2.1 Road 1: Create the basics

We follow the life-line of a factory, starting very small but steadily growing over the course of the years. In this first phase of the factory life, we observe the transition of spares management from virtually a garage to a recognized company function.

Buy, use and fix

We discussed the setting already. Actually there is no spares holding at all. Technicians just buy what they – think they – need. What is left, is kept somewhere in the production

facility. Also they might buy some more of certain parts that clearly influence the operations.

This policy is fine as long as the factory is small and the bottom line is not affected too much by this practice.

Set up a store
When the factory starts growing, obviously the required amount of spares is also growing. The first symptom is spares located everywhere and becoming difficult to find. Also the "Hands-On-Tool-Time" is reducing significantly, as the technicians spend a lot of their time on ordering and locating spares.

The logical next step is to create a proper store. Here the spares[1] are stored conventionally, using racking systems and a bin system. Also proper issuing and receiving processes are brought in place, preferably supported by the ERP system. To keep the stores clean, safe and structured, 5S[2] principles are implemented.

Also the store becomes a formal organizational element, with a stores manager and store clerks. By organizing it in such a way, maintenance becomes a "client" of the store and will be discouraged to "look and grab".

Categorize and sanitize
Up to now, spares management was primarily a maintenance activity. From a procurement point of view, the spares were not that interesting as both the spend and the number of part requests were limited. Also the financial controller had other priorities as the working capital in spares was close to zero (all stock was directly written off).

With the factory expanding further, spares management is requiring more structure and becomes a multi-disciplinary activity. The increased number of direct purchases leads to a significant work-load for the purchasing department. Also the notion rises of potential supplier benefits when standardizing and leveraging. Maintenance is starting to see the benefit of standardizing as well, after getting lost in yet another search for a specific part that has not been codified.

Hence, the need arises to rationalize and categorize the spares assortment. Rationalizing means among other things:
- Understanding again why parts are necessary (e.g. from an asset criticality or supplier availability point of view)
- Introducing an effective and unambiguous process of master data management

Categorizing means also strategizing: each category requires a strategy from different angles. The table below provides an exemplary overview.

[1] Including related goods like consumables and tools
[2] https://en.wikipedia.org/wiki/5S_(methodology)

Assortment	Sub-assortment	Inventory strategy	Procurement strategy	Physical stocking strategy
Spares - regular	**Fast/medium**	Delivery from Stock; Use statistical models, medium/high service level	Actual price lists	Minimize walking distance, or mechanize
	Slow/non	Delivery to Order	Actual price lists	Cross dock
Spares - critical	**Fast/medium**	Delivery from Stock; Use statistical models, high service level	Actual framework agreements, call off	Minimize walking distance, or mechanize
	Slow/non	Delivery from Stock; Use "decision tree"	Availability agreements at OEMs	Proper conventional ways
Chemicals	-	Stock minimum quantities, take into account shelf life	Availability agreements at OEMs	Separate, conditioned location
Heavy parts	-	Stock sufficient; handling is expensive	Actual price lists	Satellite location in production

In essence, after this step of categorization all disciplines know what to do in the field of spares management:

- Maintenance knows how to define critical spares;
- The inventory controller has rudimentary rules to manage the stock;
- Master data management has a clear protocol in case of phase in/out parts;
- Procurement is able to agree on basic contracts with their key suppliers;
- Finance can control the financial aspects, such as working capital and write-offs

2.2 Road 2: Optimise and sustain

The first road brought spares management to a credible company function with clearly defined processes. Such a state makes an operation robust for growth, but not necessarily in an efficient way.

And the factory is still growing, with more demanding directors and shareholders. With the growth, the stakes become higher. Profit is key, putting lots of pressure on uptime and spares availability. Financial health is also key, leading to pressure on working capital. Hence, the notion of conflicting interests becomes apparent. Apart from this, the environment also throws complexities in the spares arena. Think for example of more complex technology and increased risks of obsolescence.

The second road is about effectively managing these complexities, starting with basic optimisation concepts and subsequently creating additional benefits by reaching out to other disciplines than merely the stock and store function.

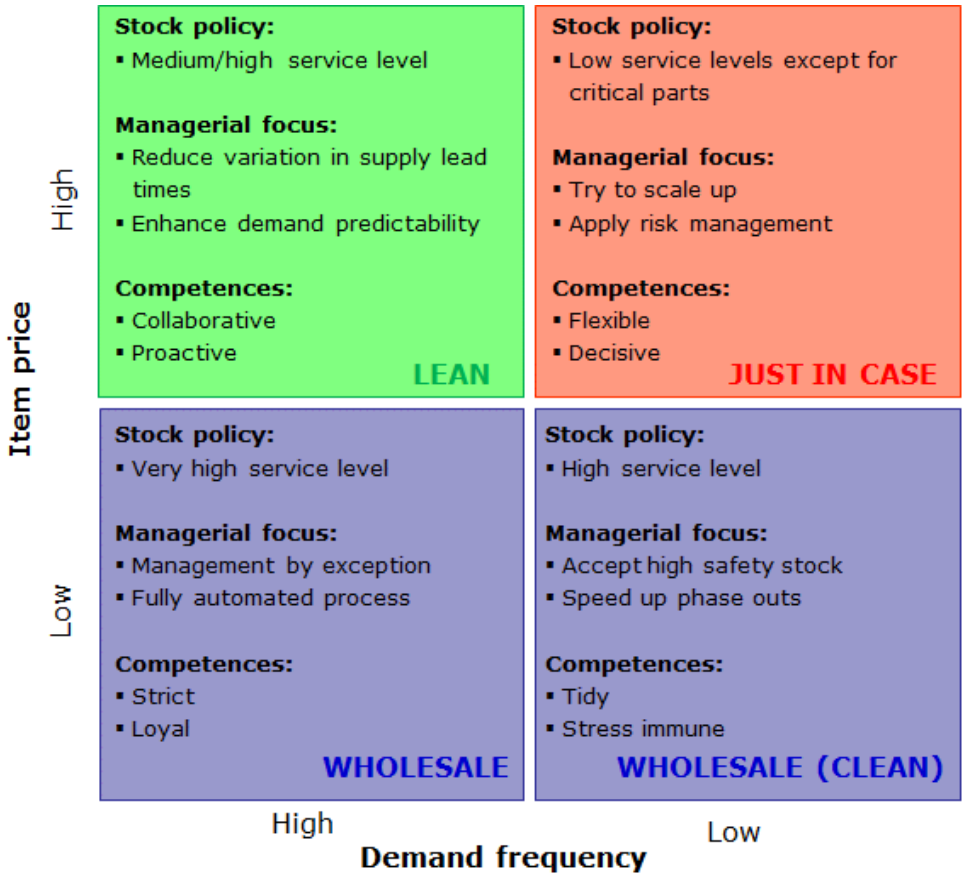
Start stock optimisation

The key question here is: how to get the most out of the working capital and the available resources. As mentioned before internal incentives become more and more conflicting, which requires differentiated strategies. Increasing spares availability and lowering working capital is just not a 1 dimensional exercise.

Practice shows that price and demand frequency are adequate discriminators for classifying a spare parts assortment. Each category in this classification demands a different approach to contribute effectively on the overall business objective.

With a very low financial risk on cheap fast movers (e.g. bolts, nuts) the company can (and must) increase spares availability for these parts by implementing a close to automated planning and buying process with high

service levels. In contrary, working capital can be reduced by being careful with the more expensive slow moving parts. The small amount of part requests for these parts does not have a substantial influence on the overall spares availability but not putting an extra turbo engine on stock can save you a lot of money. Of course, criticality changes all of this where it is more about assessing supply chain risks. The above is visualized in the following matrix.



Applying a management by exception strategy for cheap fast movers frees up time for material planners to spend it on the more difficult parts. This sounds maybe obvious but from our experience organisations struggle with this, mainly due to a relatively low level of education and specialised knowledge in logistics, planning and purchasing departments. We believe that well skilled material planners and buyers are crucial to make proper spares optimization happen.

Plan for spares supply

At this stage, we have basic contracts in place with the key-suppliers. These contracts enable the stores to replenish the stock without going through cumbersome procurement procedures each time.

Still, the lead times may be long and variable. Often the supplier behavior is taken as a given, however that does not necessarily have to be accepted. Swapping roles, suppliers often get very limited information on future orders or plans from their customers making it very difficult to anticipate (Recall the analogy between work order planning and maintenance planning).

There is a world to win when clients start sharing forecasting information with their suppliers, even when it is probabilistic information.

In turn, professional suppliers are able to anticipate and reduce lead times significantly. This certainly holds for suppliers providing mechanical devices such as bearings, belts, seals and wheel tires.

Albeit more complicated, such a collaborative supply chain might also work for electrical equipment. Failures might be more random and the risk of obsolescence is always present. Yet, precisely then it is worth investing in relations with these suppliers.

As a final note on this topic, the "royal" way would be to optimize relations with suppliers after optimizing the relationship with maintenance. That is not always a pre-conditional route. There might be quick-wins in sharing history-based forecast information with suppliers in the first place. This specifically holds for fast and medium moving parts.

Plan for spares demand

Up to now, we already got some relevant input from maintenance; the list of critical parts being the most important one. This allows the material planner to segment in levels of stock availability.

The origin of spares demand is still a black box. It would be ideal if the maintenance work order planning – via the bill of materials – would flow into the material planning and then into the procurement planning.

Unfortunately, this idea only applies to a certain extent. The logic is simple: it is often not cost-effective to replace an expensive part without a first diagnosis. Hence, the replacement of spares is often condition-dependent which complicates the forecasting of spares. We stress though that connecting work order planning is always worthwhile trying it, at least to make things visible.

It often makes sense to make the aforementioned relation a little more sophisticated. Due to the inspection-based character of maintenance, fixed or *deterministic* BOMs (Bill of Material) are only available to a limited extent. When the assets and the related maintenance regimes are more or less stationary, one can develop *stochastic* BOMs.[3] Based on demand history complemented with maintenance and engineering intelligence, the probability of a part replacement can be estimated given a certain work order. For the material planner, these probabilities give better forecasts than the initial "black box" forecasts. Below, a typical example is given.

Example: WO - Overhaul pump

Spare part	Quantity installed in asset	Probability of replacement
Propeller	1	10%
Ax	1	10%

[3] Companies like the Dutch Airforce and the Dutch Railways also refer to the stochastic BOMs as %-lists.

Bearing	2	70%
Mechanical seal	2	50%

Applying a brief statistical analysis to the above gives the material planner a good demand forecast. Once the scale of assets grows, the numbers become bigger and hence the reliability of this information on spares levels increases. In summary, maintenance and inventory control can create a more profound and effective relationship by understanding the key-mechanics of maintenance.

2.3 Road 3: Become best-in-class

The second road led us to robust and optimized spare parts management. It is now an accepted company function with clear responsibilities, skills and competences and supporting IT systems. And for many companies, maintaining this situation is good enough.

However, the ambitions of the shareholders do not fade and the factory is still growing. Actually, they already become an international player with plants all over Sub Saharan Africa. With the everlasting pressure on working capital, it needs to pursue additional angles for spares optimisation.

This road explores opportunities using buying power, as well as mathematical and technological possibilities to improve.

End-to-end supply chain optimisation

Up to now, the accepted paradigm is that spares stock should be owned by our factory, being the asset owner. At first sight, this makes sense as spares are needed "just-in-case" a failure occurs or inspections are executed creating an urgent need for a spare.

Let's take a more holistic view on the supply chain. Our factory may be impressive in size now, although the average annual need per part is still very low from a supplier perspective[4]. For suppliers to have profitable production lines minimum order quantities are imposed to the customer. In this case, these MOQ's often exceed the real customer demand. In addition, long lead times may play a role here as well.

This leads to the fundamental question: *which party is best able to manage the risks of having stock?* There is no one-liner answer to this question. However, for a number of reasons, it is worthwhile to involve the potential of the suppliers. Think of:

- The scale of a supplier is bigger;
- The product knowledge of suppliers is more advanced;
- The buying power of suppliers is higher and they have a better view on obsolescence risks.

Of course there are also many limitations. For instance, the supplier must be mature enough to handle such a responsibility. Also, there must be sufficient standardization across their clients.

Our experience shows that this step can logically follow the "Plan for Supply" phase, in the sense that our factory and its suppliers make increasingly rational and high-impact attempts to optimize the supply chain – end-to-end – taking into account the stakes of all entities.

[4] Recall the step 'Plan for spares supply'. In this step we created a better collaboration for fast and medium movers. Still a big tail of slow and non-movers remain. The latter parts are addressed here.

Mathematical optimisation
At this stage, many multi-plant companies already concluded that they use the same spares in different plants. During the phase of stock optimisation, practical arrangements have already been made, e.g. putting the very expensive parts on stock at one location[5].

There is much more potential to unlock, certainly in international networks. The current optimisation models work on a plant by plant basis, i.e. required safety stocks are determined per plant. However, this leads to unnecessarily high safety stocks in the complete supply chain since no part pooling mechanisms are used.

So-called multi-echelon models determine safety stocks across the supply chain in an optimal way. In other words: given a target stock availability at the front-end of the supply chain (the stores counters in a plant), the model allocates the stock in the supply chain in such a way that the required working capital is minimized.

In other areas mathematical optimisation can be applied as well. Think of the rotables and the components needed to repair those rotables. One can choose to put a lot of serviceable rotables on stock which can be swapped easily but is expensive in stock holding. Or one can choose to put the components on stock to be able to repair these rotables. Either way, putting them both on stock is not very wise to do.

Experience shows that mathematical optimisation may result in another 10-30% reduction in working capital after having completed regular optimisation. It does however require a centralized spare parts management department with highly skilled employees. Also a direct relation with universities, bringing state of the art optimisation concepts in practice, can be of great help.

Eliminate need for spares
As a profitable international player, our factory sets the standard on innovation as well. The production machines operate autonomously. The condition of the machines is monitored using a wide array of sensors feeding a "maintenance control tower" using IoT techniques.

Maintenance will now have a predictive character, i.e. failures can be anticipated on in advance. But the information will be probabilistic and short term in nature. For instance, the prediction can typically be: that PCB has a failure probability of 60% within 1 week. If the PCB is critical, then a preventive replacement seems logical.

Then still, these PCBs must be kept in stock to bridge the supplier lead time which is often much longer than 1 week. To overcome that problem, even PCBs can already be printed using 3D printing techniques.

So eliminating the need for spares is possible, but that means addressing both demand *and* supply. We stress though that eliminating the need for spares is not always the most cost-effective solution. But – keeping the complete roadmap in mind - our factory has the ability to choose between realistic options.

Several leading edge companies have arrived now at this stage. What binds them – apart from the technological innovations – is the very creative and open atmosphere.

[5] This is a preliminary stage of "virtual warehousing".

So, have we reached the end?
The answer is both no and yes. To the best of our knowledge, we are not aware of companies that went beyond the last stage. That is, from an implementation point of view.

However, in several innovation projects we are exploring new areas for optimisation. An appealing one is the application of artificial intelligence in spares management. In essence, algorithms are developed that are self-learning e.g. based on effects of demand and supply behavior on spares decisions.

So the journey will change over the course of time, primarily by developing new destinations.

3. Often encountered roadblocks

The road towards best-in-class is full of roadblocks. In this section, we discuss the most encountered roadblocks and proven ways to bypass them successfully.

Roadblock 1: Going around the first bend

Companies often qualify themselves as: "not ready for spares optimisation". Typically they got stuck in the phase of categorizing and sanitizing, characterized by corrupted and unstructured data and lots of direct purchases.

These companies try to solve these issues "The Royal Way", i.e. they first aim at developing an unambiguous approach to master data management, then fully clean the master data base and finally go around the bend to spares optimisation. Such a process might seem intuitively logical, but can take a very long time with the high risk of losing momentum.

A much more effective way is concurrent in nature. It is often possible to make clusters in the assortment even though the data is corrupt. For instance, the regular moving spares are easy to isolate. The same holds for rotables. Once you have the first clusters, the data can be cleaned using a master data convention[6] after which these clusters are ready to embark the optimization phase.

There are several advantages to this approach. First results are quickly achieved so successes can be shared and celebrated, creating momentum. Second, the cleaning and optimisation is often done by different people, making it possible to work in parallel. Third, during the first "waves" lessons are learned on the methodology and can be used in later, more complex waves.

Roadblock 2: Making spares optimisation a company function

At this stage, the spares are optimized implying that the right methods are implemented, a higher educated inventory controller is installed and practical tools support the inventory controller in making decisions.

As important feed-ins, demand and supply history on spares level are more or less taken as a given, always looking back to predict future events. As described in the journey, both demand and supply can be influenced, e.g. by pro-actively sharing information throughout the supply chain.

[6] There are different conventions, all with pros and cons. Our recommendation is: just pick a proven one and implement it consistently. Also: keep democracy limited….

Technically, this is no “rocket science”. However, such a practice requires various disciplines to collaborate on a tactical level. That means maintenance and procurement being able to also act on tactical level. Having these disciplines in place and working together, requires change management.

Passing this roadblock is certainly doable. Creating awareness on the benefits of such a collaboration is a very good way to start. In such a process, being empathic to possible (but often experienced) historic tensions between the various disciplines is vital to success.

Roadblock 3: Going around the second bend
At this stage our factory has optimized the spares in all their plants. A clear focus was put on those sub assortments that create the biggest impact while harmonizing the supply chain: the fast and medium movers. By sharing forecast information suppliers can anticipate in their production and delivery schedules. Also they can produce pro-actively because they know their production volumes will be sold and consumed.

But what do you do with parts for which the win-win is not clear? Think e.g. of expensive critical parts. As described in the journey, end-to-end supply chain collaboration can really be of help, involving engineering, material planning, procurement and even external parties such as suppliers.

However, collaboration is always about mobilizing people, certainly in environments in which the parts are no self-evident friends from a historical perspective. So in essence this roadblock is of the same nature as the previous one: it is about organizational entities learning to collaborate.

Hence, also here we advocate creating awareness on mutual benefits taking the history of the relation into account. However, to go around this bend a proper contractual basis is essential. Think e.g. of a framework agreement that already allows for information exchange and the addition of logistics agreements.

4. Conclusions

The purpose of this paper was to clarify the journey towards professional spare parts management, including the main obstacles that are often encountered. Of course the authors also intend to stimulate companies embarking on this journey, but at the same time to define a clear destination and to travel wisely.

The best motivator to start the journey is business pressure, e.g. pressure on working capital, on spares availability, or perhaps operational logistics costs. But it is also about making smart decisions. Think of the concurrent transition from the spares categorization to the spares optimization phase. Moreover the use of some smart decision support systems as well as tailored spares management training courses are often very effective enablers.

The number of success factors for arriving at the desired situation are limited. It primarily has to do with organizational drive, i.e. the drive to promote spares management to be a credible company function, to enhance the educational level of inventory management and to increase intra- and interorganizational collaboration.

5. Acknowledgments

The authors thank Jelmen Grundel, consultant at Gordian Logistic Experts, for his valuable on both input and visualizations.

6. References

This whitepaper follows an earlier white paper about "Pragmatism through differentiation"[7] which explains the first stages of spares categorization and optimization a little bit in more detail.

Finally, concrete implemented solutions at various clients can be found on our website: https://gordian.nl/en/clients-cases/. Can you see where they are on their roadmap?

[7] https://www.gordian.nl/wp-content/uploads/2018/01/White-paper-Spare-Parts-Management-Optimisation-v1.2.pdf

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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