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Inventory management in Maintenance environments

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1. Introduction

Let's not beat around the bush: Inventory management in maintenance environments can be extremely complicated. Certainly when it comes to the more expensive spare parts, where uncertainty is a major factor. On the other hand, inventory management for spare parts such as oil, nuts and bolts and batteries, can be done with the old familiar techniques.

We will therefore first distinguish the different spare part categories. Then we can introduce the *Vital-Essential-Desired* [VED] analysis, to distinguish between important and unimportant Stock Keeping Units [SKUs]. For spare parts in the full sense of the word we will introduce the Poisson approach to stock strategy (don't panic, top manager, I'll explain that in simple language!).

We will also consider the concepts 'corrective maintenance', 'preventive maintenance' and 'condition-dependent maintenance' to deal with problems of uncertain demand.

2. Spare part categories

In my approach there are three spare part categories:

1 *Consumables* or fast-movers

2 *Repairables* or *Rotables*

3 *Spare* parts in the full sense or (very) slow movers

2.1 *Consumables* (fast-movers)

Consumables are parts or products that are used often and where there is a more or less regular demand. Things like oil, batteries, common nuts and bolts and basic tools. Products that you can purchase practically anywhere and from different suppliers.

The terms 'often' and 'more or less', as used above, merit further explanation. The problem is that statistics are involved and that is not everyone's hobby. To put it in practical terms, 'often' means at least weekly and 'more or less regularly' means following a (statistically) normal distribution. Your tactical and more statistically knowledgeable management must be able to interpret this and select these products. Existing inventory models and strategies apply to this category. So nothing to worry about.

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2.2 *Repairables*

These are products that can be repaired. A safety stock is maintained for these parts or products, and the defective part is immediately replaced by a 'working' part.

To give an example: the catering trolleys that KLM uses for the meals on board. Something breaks from time to time. They are immediately replaced by a refurbished trolley and the broken trolley is inspected. If it can still be repaired, it will enter the repair process. If it is not possible or not worth repairing, it is scrapped. Figure 1 illustrates this process.

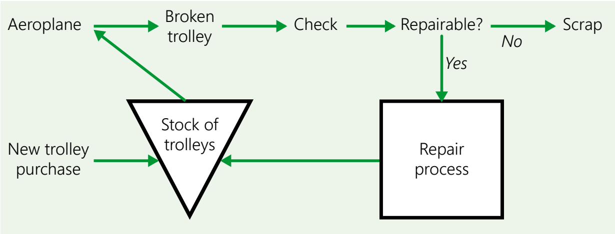

Figure 1. Trolley process

The problem here is how to decide on the (safety) stock of trolleys. Parameters involved are the variations in the delivery time (of the repair process), variations in demand (broken trolleys) and the desired delivery reliability.

Delivery reliability must often be extremely high in many maintenance environments. An installation or production facility that must be halted while waiting for a spare part costs a lot of money.

2.3 *Spare* parts in the full sense

The characteristics of a 'true' spare part are that demand for this is '*lumpy*' (0 or 1), it is a *slow mover*, it is very expensive, and it has a long delivery time. Also, the supplier often makes these parts to order. We will deal with these items in section 6.

3. Which products are important? *(VED-analysis)*

A further problem in the spare parts industry is the often immense assortment. For each component, the master data must be correct and the inventory strategy must be determined (how much to order, when to order). With tens or even hundreds of thousands of SKUs, this is often not feasible with the available staff and the MT must decide which of the products deserve attention. In 'normal' inventory management this is where ABC analysis comes in, looking at margin or turnover. See Durlinger [2019, 1]

The technical component is crucial in the spare parts industry. That is why we consider how 'critical' a given part is. What will happen if we haven't got this particular SKU in stock? This is where we make a *Vital-Essential-Desired* [VED] analysis. *Vital* means that the production process or installation goes down, but for *Desired* we still have alternatives. As we said, this is a technical determination: it is for the technical department to make. The other consideration is the financial aspect. How much money do we spend on this part? We want to pay a lot of attention to expensive parts or parts that simply involve a lot of money. On the other hand, components where little money is involved don't really merit attention. But beware, a part only worth a few pennies may well be *Vital*. Even so, we are not going to waste much time on these. We simply ensure that there are always enough so that we never run out of stock. Think of it like toilet paper. All in all, this leads us to a two-dimensional matrix as in Figure 2.

	Turnover		
	High (A)	Average (B)	Low (C)
Vital			
Essential			
Desired			

Figure 2. Two-dimensional VED analysis

The criteria for High, Average and Low turnover are set by the MT. For example, they can decide that any part with a turnover of more than one million pounds is an A-item, and parts with less than one hundred pounds are C-items.

The strategic MT does not have to make this VED / ABC analysis, it is a job for Tactical Management, but the final classification remains the responsibility of the strategic MT. Later on, inventory strategy and forecasting will be based on this classification.

We can perform this VED analysis for all SKUs, or separately for the categories *Consumables*, *Rotables* and *Spare parts* that we discussed earlier. Your job now is to ensure that your

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employees are working on the *Vital* articles at the very least.

You do not have to pay too much attention to articles with a low turnover. The strategy must be based on the principle that the stuff must simply be in stock (the toilet paper principle). Or else you can outsource inventory management of this type of item (*Fabory*, *Nedac Sorbo*).

4. Inventory strategy

4.1 *Consumables* stock

Inventory strategy is based on the importance of the product, the more or less regular demand and the delivery performance of the supplier. We have assumed that demand for *Consumables* (fast-movers) is regular, more or less, and that purchases can be made from several suppliers, so that delivery times are often short and reliable. This is in stark contrast to the situation for *Repairables* and *Spare* parts...

4.2 *Repairables* stock

The demand for *Repairables* is not as regular as for the *Consumables* (and it doesn't need to be) but the real problems have to do with the performance of internal and / or external suppliers. The long and unreliable delivery times in machine workshops are notorious, some of my customers refer to them as "*black holes in the ground*". However, we must realise that the demand for capacity in a workshop can vary enormously. They often don't know in advance when something may come in and just as often they don't know what. This makes it difficult to estimate the necessary repair capacity. If there isn't enough lee-way in the planning, problems will be noticed immediately. One way to reduce this variation is the *maintenance concept*.

5. Maintenance concept

In principle we can distinguish three maintenance concepts:

1. Corrective maintenance
2. Preventive maintenance
3. Condition-dependent maintenance

5.1 Corrective maintenance

This concept was often used in the past, and still is. The basic principle is *"if it ain't broke don't fix it"*, as promoted by T. Bert Lance. During the Carter administration (1977) he made the claim: *"I can save Uncle Sam billions if we adopt this simple motto"*.

This principle can indeed save money in the short term, but in the longer term it may cost a lot more. Also, you don't want some component in a Boeing 747 to spontaneously fail at a height of 10 km or, somewhat less dramatically, an old diesel locomotive to break down in the back of beyond. Or, closer to home, you don't want the timing belt in your car to break spontaneously in the middle of a rainy night. All good reasons why Professor Geraerds developed and promoted the *preventive maintenance* concept at Eindhoven Technical University as early as the 1980s (see compilation on the occasion of his retirement [1991]).

5.2 Preventive maintenance

At first sight, it seems more expensive: *fix something which ain't broke?* But now you can start planning. You have eliminated the demand variation, to a large extent, so that you can make do with much less stock. In addition, planning in maintenance environments can be much more accurate. You know when what is going to be done. Car maintenance also follows this principle: a timing belt is replaced earlier, before it is likely to fail. Both headlight bulbs are replaced when one of them goes. On aeroplanes the tires of the landing gear are replaced after an x number of starts, and so on.

5.3 Condition-dependent maintenance

A refinement of preventive maintenance, or a compromise between preventive and corrective maintenance, is to periodically examine the condition of the part and base the spare time on the result. By measuring hairline cracks in the material, for example, or metal particles in the oil. This keeps you just ahead of the actual failure point associated with corrective maintenance, while still achieving many of the benefits of preventive maintenance: lower stocks and improved planning. Of course this is all based on statistics and we will sometimes be caught out by a spontaneous failure, but the bulk of the uncertainty can be removed.

6. Spare parts in the full sense

As mentioned earlier, stock management of spare parts in the full sense is a problem. This is due to the high purchase price, the 'lumpy' nature of the already low demand and the long delivery time from the supplier. Furthermore, the high costs involved with the downtime of an installation must be considered. In this case we are thinking of components that cost half a million or more, are replaced on average once a year and have a lead time of more than six months with a large deviation in this lead time. For this type of component, nobody will decide to "just keep ten in stock to be safe". This is where the *Poisson* approach is the way forward. No need to get stressed – the principle is quite simple. The calculation is a different matter entirely, but you can leave that to the experts. As a top manager, you just have to see if you like the results.

To give an example. Suppose you have a component for the offshore in your assortment. When this part fails, your customer immediately sends a helicopter with a team of strong men to collect a spare. On average you sell two of these components each year. To keep things simple, let's assume that the lead time is six months; so you need one component per lead time.

7. The Poisson strategy

The Poisson strategy is as follows. There is one component in stock. When this is sold, you immediately order a new one from your supplier and it arrives exactly six months later *(the perfect world* ☺*)*. Figure 3 shows the initial situation, with one component in stock.

Figure 3. Initial situation

Now a customer comes to purchase this component. We sell it and immediately order a new one. This arrives exactly six months later (see Figure 4).

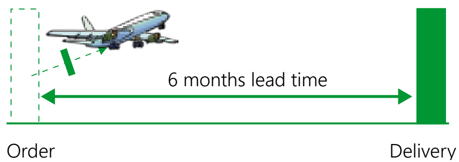

Figure 4. Situation after part is sold

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So when do things go wrong? That happens the moment another customer comes along for the same component in the course of the lead time. We don't have any more in stock. But what is the chance that this will happen? This depends both on the average demand during the lead time (just one component in our case) *and* on the demand distribution. In cases like this, where the average demand is small during the lead time (small being less than five), there is a *Poisson* distribution. Your experts can calculate the chances.

Let me warn you that the chance that another customer arrives within the lead time is equal to 37%. In other words: your service level is only 63%. Not very good for a spare part environment. So if we assume that having only one of these components in stock is not an option, what happens if we stock two? We sell one and immediately order another each time. We still have one in stock, and one more will arrive in exactly six months. When do we get in trouble now? Right, things go wrong if more than one component is requested within six months. The chance of this happening, in this case, is 3%. And if we don't consider that good enough, we'll have to start with three in stock. Your experts can tell you what the investment should be for any given service level. Then it's up to you, top management, to make the strategic decision.

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8. Summary

What should you do, as top management? First perform a VED analysis and then focus on the V components. After that, introduce a preventive or condition-dependent maintenance principle to bring your planning under control.

9. Literature

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TUE- Samsom/NIVE

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Durlinger Essential: ABC-analysis

Whitepaper www.durlinger.nl

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Paul lectured at several universities and has twenty years of experience as a senior consultant. He sees it as his mission to make difficult concepts readily understandable.

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