What You Need to Know About Forecasting and Planning Service Parts

Smart Software, Inc.
Four Hill Road, Belmont, MA 02478  t: 617-489-2743  www.smartcorp.com

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Executive Overview

• Planning for service parts is generally more complex than for parts used in the production of finished goods. Service parts are sold by themselves, not as part of a manufactured product. They tend to have lower usage rates and much more volatility in their demand patterns than parts used in production. Long lead times and difficulty in specifying when and where a part will be needed make demand planning more difficult.

• A significantly large percentage of the items in service parts inventories, often as high as 70%, exhibit “intermittent” (“slow-moving”, “sporadic”), demand. Accurate forecasting of parts that have intermittent demand is critical for determining the proper amount of safety stock, and ultimately the amount of inventory you put on the shelf at each stocking location.

• Intermittent demand is present where demand history contains a large percentage of zero values, interspersed with spikes of non-zero demand that occur on a seemingly random basis. Forecasting intermittent demand is extremely difficult because there is no apparent structure or pattern to the data. Traditional forecasting methods don’t manage this well.

• There are typically five traditional methodologies used to forecast intermittent demand: “gut feel,” exponential smoothing, Croston’s Method, Poisson Models, and Reliability Models. While all have their appropriate uses, none are appropriate for service parts forecasting. Too often, they produce misleading inputs to inventory control models – with costly consequences.

• Smart Software developed and patented a technology for accurately forecasting intermittent demand -- the Smart-Willemain method. This method is based on statistical bootstrapping, and provides fast, realistic forecasts of intermittent product demand over a fixed lead time. It is an empirically based method that makes no assumptions about the data and does not assign any predetermined shape or pattern to the distribution of forecast results.

• This proven method, tested in dozens of customer environments, is integrated in Smart Inventory Planning and Optimization, Smart Software’s cloud-based suite of applications. Experience has shown that the Smart-Willemain technology has been nearly 100% accurate at estimating required safety stock and inventory stocking requirements to meet desired service levels over a lead time.

• Customers, such as Montreal Transit Corporation, Kratos Space group, Prevost Parts, and Metro-North Railroad, are achieving impressive results reducing inventories, saving millions of dollars, improving fill-rates and customer service levels, increasing cash flows, and achieving these gains with fewer resources.
What You Need to Know About Forecasting and Planning Service Parts

Introduction

Service parts forecasting and demand planning present some unique challenges. The biggest of these is the presence of intermittent demand for up to or exceeding 70% of the items in inventory. Until recently there were no tools adequate for accurately forecasting those items and estimating how much safety stock to put on the shelves.

This white paper will explain why service parts are so difficult to forecast, discuss some of the methods commonly used for service parts forecasting, and present the evolution of highly specialized, effective solutions. You will learn that commonly used methods try to impose some order on data that's not at all orderly, resulting in inaccurate forecasts and inputs into planning models. While they can produce reasonable estimates of average demand per period when demand is intermittent, more than that is necessary to estimate of much inventory you'll need to achieve a specified service level over a replenishment lead-time.

We will then introduce a patented methodology that is only found in Smart Software products. It works successfully because it is empirically based, makes no assumptions about the data, and does not attempt to impose order where there is none. It delivers accurate safety stock estimates and inventory stocking level requirements to meet a desired service level over a lead-time, greatly reducing the risk of stocking out without overstocking.

Throughout this paper, we will present short case studies that demonstrate inventory cost savings of millions of dollars, impressive improvements in fill-rates, and increases in service levels. You will learn how hundreds of companies are finding hidden cash buried on their warehouse shelves by using the technology described here.

The Service Parts Challenge

Service (spare) parts and related aftermarket services account for 8% of the gross domestic product (GDP) in the U.S., with U.S. consumers and businesses spending more than $700 billion each year on parts and services for previously purchased assets, such as automobiles, aircraft, and industrial machinery. On a worldwide basis, expenditures on such aftermarket parts and services total more than $1.5 trillion annually and account for 20-30% of revenues and about 40% of profits for most manufacturers of durable goods.

For companies that manufacture, distribute, or hold large inventories of service parts, the demand planning challenges are strikingly similar:

• They must manage their parts inventory requirements to meet the repair and maintenance needs of products whose useful lives could span decades.

• Because of the prevalence of time-based service agreements, they often need to achieve high service levels to help ensure zero downtime.

• They must also contend with the inevitable problems of maintaining inventories of expensive, slow-moving parts that are subject to obsolescence.

• And, they may need to do all of this in a multi-location environment that includes central distribution centers, regional warehouses, and branch offices, each with different stocking strategies and requirements.
By their very nature, service parts are generally more complex than their counterparts used in the production of finished goods items. First, service parts are sold by themselves, not as part of a manufactured product. This tends to result in lower usage rates and much more volatility in their demand patterns. Long lead times and difficulty in specifying when and where the part will be needed next can make their supply chains more complex. For these reasons, many companies must tie up cash in extra safety stock to ensure that service levels are maintained at a competitively high level. In addition, unlike parts used in production, service parts must be stocked throughout the entire life of the product, meaning that inventory planners need to manage significantly more SKUs on the service part side of the business. All of these factors make the forecasting and demand planning of service parts especially challenging.

Demand planning is particularly difficult for service parts operations where demand is intermittent, or slow-moving. A significantly large percentage of the items in service parts inventories, often as high as 70% or more, exhibit this characteristic. As we will explain, intermittent demand is very hard to forecast, and until recently there was no accurate method of forecasting this type of demand.

However, accurate forecasting of parts with intermittent demand is critical for determining the proper amount of safety stock, and ultimately the amount of inventory to stock at each location. Not having the right part at the right time at the right location can cause unacceptable downtime, lost revenue, and reduced customer service levels.

Success @ Montreal Transit

Montreal Transit Corporation (MTC) has a fleet of over 1700 buses and 749 metro-cars. MTC stocked 200,000+ parts, many with intermittent demand, valued at $33.6 million. About $10 million worth of parts were inactive. Most of the time, safety stock, reorder points and reorder lot sizes were determined by “best guess.” Consequently, overall parts availability was only 76%.

Since implementation of Smart Software’s SmartForecasts®, MTC’s stock management parameters have greatly improved by using objective forecasts rather than simply averaging the past, and it enabled them to react rapidly when demand patterns changed. MTC can now forecast any specific item more quickly and accurately - even the more than 50% with intermittent demand. In an environment where an out-of-service vehicle disrupts the system, SmartForecasts helped MTC meet the very high service levels its operating units demand.

Finally, with SmartForecasts MTC can forecast all of its 200,000 parts on a regular basis, and has achieved an 18 percent increase in parts availability (to 94 percent), with a 13% reduction of existing parts in stock of $4.4 million CAD (to $29.2 million). In addition, the company reduced its inactive inventory by 24%.
The Intermittent Demand Problem

Intermittent demand is present where demand history contains a large percentage of zero values, interspersed with spikes of non-zero demand that occur on a seemingly randomly basis.

For items like the one shown in Figure 1, there is no apparent structure or pattern to the data, a phenomenon that most traditional forecasting methods don't manage well. The reason is that they ignore the special role of zero values when analyzing demand, as well as other key characteristics of intermittent data. Traditional methods can identify visually obvious patterns in the demand data, such as trend and seasonality, but when these regular patterns are not detected, the methods tend to simply “smooth over” what they interpret as outlier or anomalous values. Neither are they suited to detecting and taking account of the “feast or famine” nature of the demand.

A number of vendors claim to offer solutions to the intermittent demand forecasting problem that use traditional forecasting methods, or variations of them. While conventional statistical forecasting methods can produce credible forecasts of the average demand per period when demand is intermittent, they cannot produce accurate estimates of a more complex but critical result: the entire distribution of possible lead time demand values (i.e., total demand over a replenishment lead time). Too often, what they do produce are misleading inputs to inventory control models—with costly consequences.

Figure 1 plots the demand over 36 months for three intermittent part items (shown in red, blue and green). Only in months 17 and 32 was there non-zero demand for all three items. Many months had no demand at all, and when demand did appear, its level varied erratically.

For each intermittently demanded item, it is vital to have accurate forecasts of the entire distribution of all possible lead time demand values—not just a single number thought to be the average or most likely demand per period. These forecasts are key inputs to inventory control models that recommend correct procedures for inventory management, such as the timing and size of replenishment orders (reorder points and order quantities). They are particularly essential in service parts environments, where they are needed to accurately estimate optimal service level inventory requirements for satisfying total lead time demand (e.g., the minimum inventory and safety stock necessary to ensure a 95 or 99 percent likelihood of not stocking out of an item while awaiting replenishment).
Problems with Traditional Approaches to Intermittent Demand Forecasting

We've identified five methodologies typically used to forecast intermittent demand. Except for the first method, they all have appropriate applications for demand planning. However, when it comes to forecasting intermittent demand, the use of any of them can have serious implications for the ability of organizations to meet service level requirements and achieve balanced inventories.

“Gut Feel” is the most common approach to forecasting intermittent demand. A subjective, judgmental approach is not feasible when you are dealing with thousands or tens of thousands of items, and only provides a single-number estimate of demand. In addition, this method can unintentionally but incorrectly predict trends in demand, based on expectations, resulting in under-stocking or over-stocking inventory. We have even heard anecdotal evidence from an aerospace executive that his company’s forecasts tended to be too high or too low depending on the mood of his planners the day they made the forecasts.

Exponential Smoothing is the most commonly used statistical approach, but it is inadequate for the specialized problem of demand for service parts. Exponential Smoothing is designed to estimate average demand, not reorder points. To get forecasts of inventory needs, users of exponential smoothing must tack-on an assumed probability distribution of lead time demand values resembling a “normal” bell-shaped curve. However, where there is intermittent demand, the actual demand distributions don’t look anything like a bell-shaped curve. They often have more complicated shapes, such as only taking on certain values (e.g., 6, 12, 18 etc for six-packs) or being multimodal (i.e., having more than one peak value or “hump”).

Croston’s Method is a variant of exponential smoothing that copes better with the unusual patterns of intermittent, slow-moving items. While Smart Software has found that Croston’s method is more accurate than simple exponential smoothing for forecasting the average demand per period, our research found that it is actually less accurate at forecasting inventory needs. And, like exponential smoothing, it assumes a bell-shaped curve for the distribution of total demand over a lead time.

Poisson Models recognize that demand is more or less random. In this sense, this method roughly matches the pattern of demand for service parts. However, Poisson Models have two serious weaknesses when applied to service parts forecasting. First, while distributions of lead time demand are not bell-shaped, neither are they Poisson-shaped. Second, Poisson Models ignore the fact that demand in one time period very often tracks or correlates with demand in the previous period. (This phenomenon is called “autocorrelation” and is present in perhaps 30% of items.)

Finally, Reliability Models assume that demand for service parts can be predicted from the physical wear-and-tear of working parts. While this might be true for some parts with predictable usage, such as a fan belt or brake pad, there are many parts that may need replacement randomly or wear out faster under extraordinary conditions. Reliability models impose a tremendous data cost on the forecaster, as well as the entire service organization – especially when thousands of items are being used. To predict demand one would have to keep a tally of how many parts are in service, how many hours of operation each part has endured, and how much wear occurred during those hours. Furthermore, these data are worthless without a reliability model relating part use to the probability of replacement. Most service parts distributors do not have the expertise to make a reliability model for each part type nor access to customer data about part usage.
The Smart Way to Forecast Intermittent Demand

Smart Software proposed research to the National Science Foundation (NSF) that it hoped could remedy the shortcomings of the traditional forecasting methods discussed above. The goal was to come up with a new method that would enable companies with large inventories that have intermittent demand to accurately forecast those items. If it could be done, the economic impact on hundreds of thousands of companies around the world would be revolutionary.

Given the potential economic impact, as well as the credentials of the research team, NSF awarded a Small Business Innovation Research grant to Smart Software and a small group of researchers at Rensselaer Polytechnic Institute, in Troy, New York. The group at Rensselaer was under the direction of Dr. Thomas Willemain, a professor in the Department of Industrial and Systems Engineering and a co-founder of Smart Software. In its research, the combined team proved that you could accurately forecast intermittent demand using a combination of known statistical techniques used together in a novel, proprietary

Success @ Kratos Space group

The Kratos Space group within National Security technology innovator Kratos Defense & Security Solutions, Inc., produces COTS software and component products for space communications, tailored products for individual customers, as well as complete satellite and terrestrial ground segment solutions. In the tailored marketplace, the past does not provide a usable forecast for the future, and the demand is completely intermittent. Short forecast horizons and long component lead times makes competitive bidding for new projects difficult, where time to delivery is crucial.

Their is a highly demanding market often requiring engineered-to-order systems with exceptional performance and rapid delivery cycles. Kratos pursued a hybrid planning approach, combining sales planning by its business development team with statistical forecasting from Smart Software. This allows them to make smarter decisions related to purchasing and inventory management. Over the past three years this approach has allowed Kratos to reduce material cost. Moreover, Kratos is able to work with its Contract Manufacturers to reduce stockout risk and achieve shorter delivery commitments.
way. In 2001 the U.S. Patent and Trademarks Office granted Smart Software a patent on the method, which has since been dubbed the Smart-Willemain Method.

Subsequently, Smart Software integrated this new technology into its offerings. Using Smart’s method of forecasting intermittent demand, customers have been able to realize nearly 100 percent accuracy in forecasting service level inventory requirements. In the process, they’ve been able to forecast all of their parts inventory items on a regular basis, uncover and dispose of obsolete inventory, reduce overstocking and understocking, save millions of dollars, and realize greatly improved customer service levels.

The Smart-Willemain method enables customers to achieve such results because it’s based on a powerful modern statistical technique called bootstrapping. It provides fast, realistic forecasts of intermittent product demand over a fixed lead time. It does this by using samples of historical demand data to create thousands of realistic scenarios that show the evolution of cumulative demand over a lead time. It is an empirically based method that makes no inappropriate theoretical assumptions about the data and does not assign any predetermined shape or pattern to the forecast results. And unlike the other statistical methods mentioned above, this method takes account of a key characteristic of many intermittent demand patterns: autocorrelation. Autocorrelation creates the frequently observed “feast or famine” phenomenon in which non-zero demands tend to occur in bursts, with long periods of inactivity between bursts.

Because the Smart-Willemain method gives a forecast of the entire distribution of lead time demand and not just a single-number estimate, it can provide the type of planning information that service/spare parts organizations require for their intermittently demanded items—fast, reliable safety stock and reorder point calculations for any desired customer service level.

Figure 2 plots the demand (red line) for one part over 48 months. Twenty of the months saw zero demand. When demand was not zero, it came in bursts and varied erratically. The forecasts appended to the demand history show the projected average and range of demand for each of the next six months. The blue histogram shows the distribution of total demand that might appear over the 95-day lead time. Marked on the histogram, left to right, are the forecasted 50th percentile of lead time demand, the forecasted average lead time demand, and the current reorder point for that item. The height of each bar indicates the number of simulated future replenishment intervals which have a total demand falling into the region of the bar. In this example, there are many scenarios with lead time demand exceeding the current reorder point, suggesting that the service level for this item may be too low.
Impressive Immediate Results; Continuous Improvement Over Time

Typically, big changes happen on a staged basis over time as the information about parts demand and safety stock requirements accumulate. For example, consider the experience of Smart Software customer Metro-North Railroad (MNR), one of the largest commuter rail system in the US.

Sixty percent of MNR's inventory experiences intermittent demand. The company found that the rule-of-thumb and moving average forecast methods it was using were inaccurate, risky, and reactive. When a directive came from upper management to reduce costs in its repair and maintenance operations, MNR searched for a software system that would give them a reliable, proactive estimate of likely future demand/consumption. In a competitive evaluation of potential solutions, SmartForecasts was three times more accurate than its nearest competitor.

MNR's cost savings we achieved through a three-stage process:

Stage 1 – Improvement of internal processes. By thinking hard about its basic workflow and processes, MNR reduced its parts inventory by approximately $7 million in this stage, from $89 million to $82 million. Further savings required adoption of Smart Software's planning technology.

Stage 2 – Introduction of Smart Software's forecasting and inventory optimization technology. MNR established new, right-sized safety stock levels and re-order points to achieve required service levels. MNR achieved a net $4 million in savings at this stage by rescheduling or cancelling planned purchases as it identified overstocked items, while also increasing purchases for items found to be under-stocked.

Stage 3 – Achievement of new inventory equilibrium. Parts consumption over time will gradually reduce inventories to the new, lower levels necessary to achieve service level goals. In MNR's case, this period may take two or more years, and is expected to yield an additional 15% inventory reduction.

In Year 1 of its plan, MNR undertook an internal cost reduction initiative that reduced parts/materials inventory by approximately $7 million. Then, early in Year 2, MNR started implementing SmartForecasts and, almost immediately, found several million dollars in excess inventory purchases that were identified in a small scale study of only 7 wheel/axle parts. Subsequently, an analysis of $2.6 million worth of parts identified 354 overstocked items, of which 13% had open inventory orders. In a little over a year, Metro North Railroad (MNR) achieved a net savings of almost $4 million in inventory reductions across all of its 14,000 actively managed items.

In a phased inventory reduction (illustrated in the diagram to the left), inventories are optimized as savings continue to increase. By Year 5, MNR hopes to balance its parts inventories at a level about 15% less than they were when they started the project.
Success @ Prevost Parts

Prevost Parts, a division of Prevost Car, part of the Volvo Bus Corporation, uses SmartForecasts to more effectively distribute parts to the North American motor coach and transit bus markets. To serve its clients, Prevost maintains seven North American locations with over 25,000 active parts, 70 percent of which exhibit intermittent demand.

Prevost selected SmartForecasts over SAP’s demand planning system and several other best-of-breed applications, in large part due to Smart’s unique solution for intermittent demand forecasting.

In just 3 months following SmartForecasts’ implementation, the company’s backorders and lost sales decreased 65% and 59%, respectively, and fill rates increased from 93 to 96%. As Prevost Parts’ logistics director commented, “We need to have the right parts in the right place to support our customers. SmartForecasts helps us to not only improve our inventory allocation but also significantly reduce transportation and inventory costs.”

Conclusion

The ability to obtain accurate inventory and safety stock estimates is crucial in helping organizations balance parts inventories and reduce associated carrying costs, while maintaining or improving service levels. By achieving optimal inventory solutions, service parts operations are able to improve cash flow and more efficiently deploy corporate inventory, financial, and personnel assets, while delivering better service to their customers. These kinds of results are being realized by scores of organizations around the world using Smart Software’s pioneering intermittent demand technology to forecast demand for their service parts.

If you would like to learn more about the success of Kratos Space group, Montreal Transit Corporation, Metro-North Railroad, and Prevost Parts, please visit the following links on our website:

**Kratos Space group**
- [Engineering to Order at Kratos Space – Making Parts Availability a Strategic Advantage](#)

**Metro-North Railroad**
- [Smart Software Helps Metro-North Railroad Keep the Trains Running On-Time](#)

**Montreal Transit**
- [Smarter Inventory Management](#)

**Prevost Parts:**
- [Driving Better Auto Aftermarket Parts Distribution at Prevost Car](#)