



*Reduction of the excess obligation and processing costs
 associated with purchase orders marked for cancellation at
 Besl APac*

Master Design Project Industrial Engineering and Management

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Executive summary

Operating in the highly volatile semiconductor market, material management at Besi APac is a continuous challenge. The internally used MRP system presents new recommendations to reschedule or cancel orders to purchase materials from suppliers on a daily basis. Orders which need to be cancelled are especially a concern in Besi APac because they represent an excess obligation and involve high processing costs. It has been shown that the high open value and number of PO lines which are marked for cancellation is influenced both by daily new POs which are marked for cancellation, but also is in large part due to POs remaining open in the system while they are marked for cancellation.

Root-cause analysis shows that external variability in the form of changes in the demand, customer order cancellations and forecast changes are the main contributors to cancellation recommendations. However, manually placed purchase orders still contribute to 24% and should be addressed before applying any dampening or buffering methods to external causes. Five root-causes have been identified for these manual orders on which three different design recommendations are made: (1) Restriction of manual PO entry and only allowing manual purchase requisitions in necessary cases such as call-off of expired Quantity Contracts; (2) Use of a sales order request form to enter manual demand in the system in cases of consigning material from one supplier to another and for pre-order requests; (3) proper control measures for purchases at E level. These recommendations are expected to reduce the value of new PO cancellations by 24% and the number of new PO lines by 6%.

Root-cause analysis has shown furthermore that improvements were possible in the prompt cancellation of POs and that better monitoring of POs open for longer than 5 days was required. It was found that for prompt cancellation, current efforts to improve the successful cancellation rate within 5 days have already been quite successful but proper accountability of cancellation POs is lacking and now primarily lays on the purchasing department. It has been recommended therefore to management to consider measures in the future to shift this responsibility to persons causing the PO to need cancellation. Management should also consider how the focus on the current KPIs causes a possible neglect of cancellations. How the priority can be shifted to PO cancellation and if an extra KPI is of benefit in this case however needs future research. As well it has been proposed to implement a monthly review of cancellations to better monitor the status of negotiation and make decisions to charge out and cancel obligation sooner

The suggested improvements lead to a reduction in the open value of and number of lines of PO lines that are required to cancel at any time, and in effect to reduce the excess obligation that Besi currently is exposed to and the processing costs associated with negotiating and cancelling of the PO lines.



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List of abbreviations and definitions

Abbreviation	Meaning
PO	Purchase Order
PO line	One item in a Purchase Order
ERP	Enterprise Resource Planning
SAP	Systems, Applications and Products
PlanOrd	Planned Order
ProdOrd	Production Order
PurReq	Purchase Requisition
QC	Quantity Contract
BBP	Besit Business Partners
DA	Die Attach
PP	Packaging and Plating
VP	Vendor Parts
CMO	Complete Module Outsource
FP	Fabrication Parts
F items	Items with procurement setting in system “to be purchased”
E items	Items with procurement setting in system “to be made in-house”



1. Introduction

The semiconductor market is highly volatile and exhibits seasonality driven by product launch cycles of consumer electronics (Sun and Rose, 2015). To stay competitive as a semiconductor assembly equipment manufacturer in this market, Besi N.V. needs to offer a large variety of products which are generally low in volume. Furthermore, the market is highly competitive on quality, lead time and cost. To maintain healthy profit margins even in times of low demand, Besi's strategic objective is to reduce the costs and increase the scalability of its operations (Besi N.V., 2018).

The high volatility of the semiconductor market results in unpredictability of the demand and frequent changes in customer orders. It is well known that this uncertainty on the demand can lead to distortion in the information of inventory requirements higher in the supply chain via the bullwhip effect (Lee, Padmanabhan and Whang, 1997). (Cheung and Zhang, 1999) showed how customer order cancellations specifically can affect this distortion in inventory information higher in the supply chain and as a result increase the total operational costs due to waste of time and associated costs of order processing, but also cancellation fees for purchase orders and inventory holding costs for goods received that are later not needed.

This research focusses on the operations at Besi APac in Malaysia, where the machines are produced. Because of the market volatility and the product variety, material management at Besi APac is a continuous challenge. Purchase orders (POs) to procure material from suppliers are continuously rescheduled to match changes in demand forecasts. A high percentage of outstanding POs are required to cancel in Besi APac is especially problematic as it means that there exists a high open obligation to suppliers at any time for goods that are apparently not needed. Because of this, the management of Besi APac has requested an investigation into the root causes of these cancellations and an improvement to their process such that the total obligation on outstanding purchase orders needing cancellation and the associated processing costs will be reduced. Naturally, it is expected that the high value of POs that are marked for cancellation every day is directly linked to fluctuation of demand and requirement changes, however there may also be internal process factors leading to the high open value.



2. Problem analysis

The what-why analysis model is used to translate the original problem as supplied by management into a clear problem statement (Annamalai *et al.*, 2013). This is done by asking first why Besi would want to solve the problem. This gives the underlying reasons the problem should be solved. Next it is asked what the possible causes are leading to the problem.

2.1. Why does Besi want to solve the problem?

Henk Jan Jonge Poerink is senior vice president global operations of Besi N.V. and managing director of both Besi APac and Besi Leshan. Henk Jan reports to the CEO of Besi N.V. The primary motive of the CEO is to satisfy the shareholders' profit by maintaining a gross margin within a range of 53-57% throughout the year (Besi N.V., 2019). Because Henk Jan reports to the CEO on the Asian operations, his primary motive in reducing PO cancellations at Besi APac is to contribute to a reduction of the costs in Asia.

Ming-Chee Liaw is the senior director of the material management department, which consists of both procurement and purchasing. For her, the problem of PO cancellations is a management problem. The material department has the job to ensure on-time arrival of items needed for production. Rescheduling and cancellation of POs is an activity that takes up a large part of the work inside her department. Cancellations require frequent negotiation with suppliers, for which a lot of work hours are used. This increases the overhead costs associated with her department. Purchasers themselves have also complained (see interviews in appendix B) that they spent too much time on the rescheduling and cancellation of POs. It is however not known how much time they exactly spent on the cancellation of POs as this is not being tracked.

Hairil Amir, manager of procurement, indicates that the relation with suppliers is important for his department in order to be able to negotiate prices and work together with suppliers closely. He believes that frequent cancellations of purchase orders are negatively impacting his department's ability to sustain or improve relations with suppliers. Research supports this statement: suppliers in the semi-conductor supply chain have been shown to penalize buyers for unreliable order forecasts by providing them lower service levels (Terwiesch *et al.*, 2005). A survey held under the suppliers of Besi APac showed that 64% of the suppliers indicate dissatisfaction with order forecast information of Besi APac and 46% are dissatisfied with the rescheduling and cancellation of POs (Liaw, 2018).

2.1.1. Open obligation on purchase orders needing cancellation

The total value of open POs as of April 23, 2019 is 53.5 million MYR. Because of changing demand as calculated in SAP, 34% of purchase orders have to be pulled in on this day because they are needed for production sooner, 21% can be pushed out to a later date and 14% of POs have to be cancelled because the demand has fallen away for the item in the system, as can be seen in Figure 1.

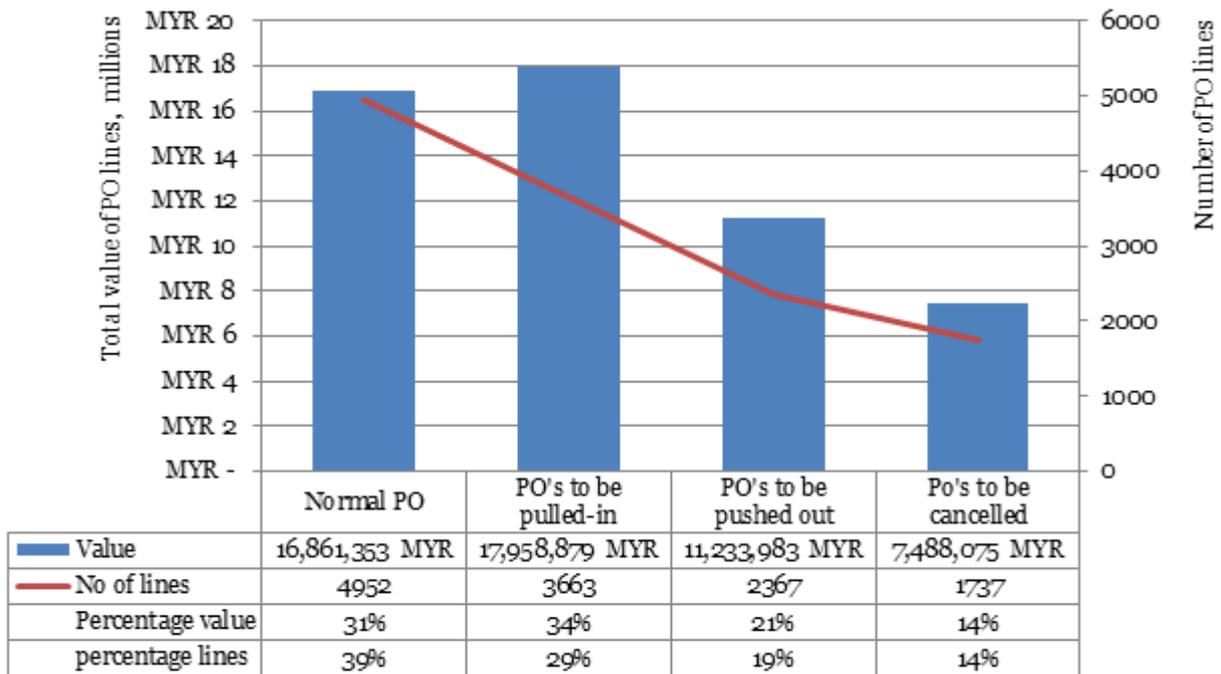


Figure 1. Breakdown of the total open value and number of POs into the portions that did not have an exception (Normal POs), the portion of POs that were required to be pulled in, POs pushed out and those which had to be cancelled as of April 23, 2019.

This means there is an obligation of 7,488,075 MYR on this date for all POs that are released to the supplier already but for which there is thought to be no need for anymore in production. Besi would like to reduce this open obligation as much as possible and would like the root-causes of these obligations. The problem owners view levels under 10% to be normal in the industry and anything above as excessive. The course of the obligation on POs that need to be cancelled over time is shown for the period of February 2018 until March 2019 in Figure 2. On average, it can be seen that the value of POs to be cancelled has been higher for the last year, averaging on 9,894,767 MYR for this period.



Figure 2. Daily value of POs that are required to cancel, meaning the demand has fallen away for the item. Data is captured from the period of February 1, 2018 to March 6, 2019.

In Figure 3, the daily number of total open PO lines and the percentage of lines requiring cancellation are shown for the same period of February 1, 2018 to March 6, 2019.

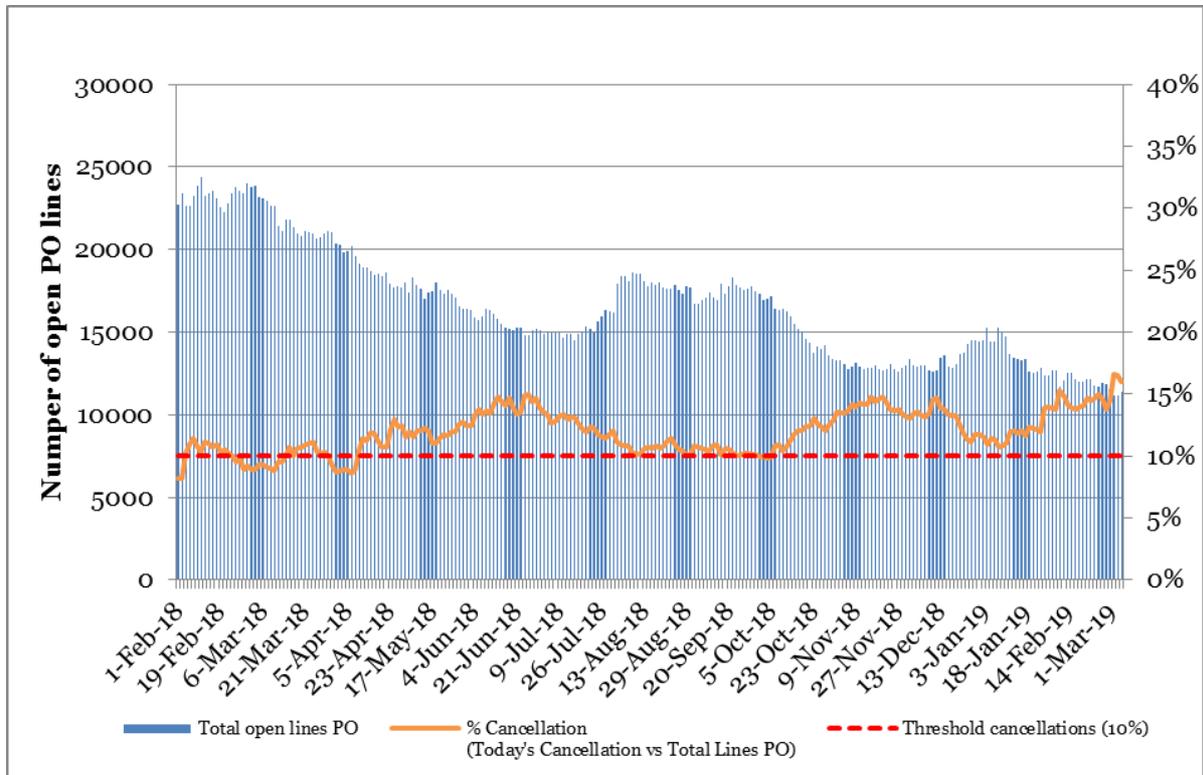


Figure 3. Daily number of total open PO lines in SAP and percentage of POs with cancellation relative to total open POs. Managers have indicated the threshold for the percentage of PO cancellations should ideally be at 10%. It can be seen from here that during ramp-down periods, cancellations go up and during a ramp-up, cancellations go down.

Henk Jan, managing director of Besi APac, estimates that the total realized cost due to the cancellations of POs is 30-50% of the value of POs to be cancelled at any time but it is currently not clear what the exact total damage is from these cancellations as not everything is measured. Below a breakdown is provided to show the different type of costs that result from the cancellations. As well, the amount paid due to obligations in previous years and the amount still requiring cancellation of those years is shown.

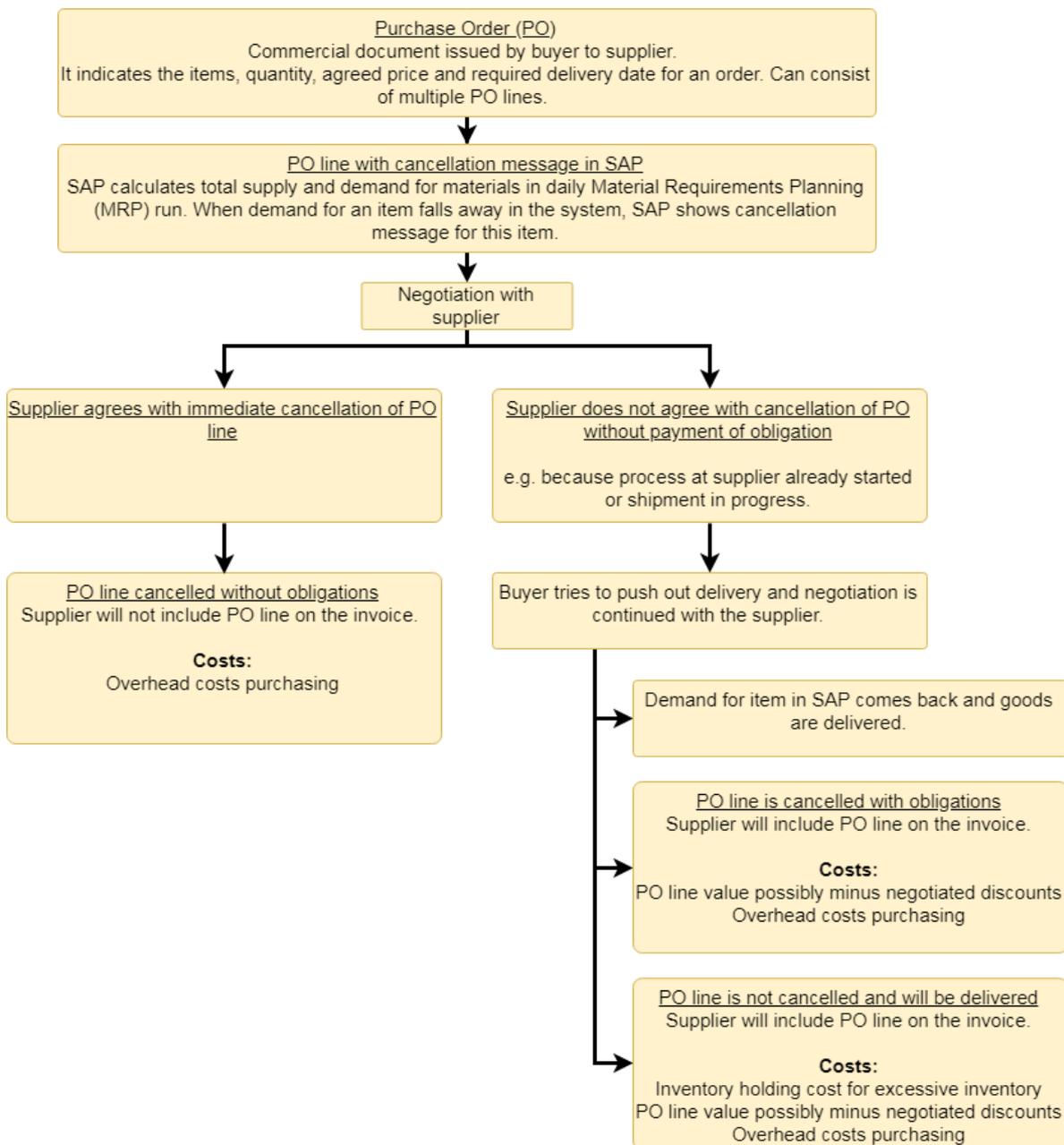


Figure 4. The cancellation process for a PO or PO line is displayed here. Costs associated with PO cancellations depend on the outcome of negotiation between purchaser and supplier.

The process that starts when a PO line is required to be cancelled is shown in Figure 4. A PO line gets a cancellation message when the demand for the associated item is lower than the supply in SAP. The buyer then starts negotiation with the supplier to cancel the PO. The costs depend on the outcome of this negotiation. If an order is cancelled before the production at the supplier started, it may be possible to cancel the PO line without obligations and the cost will only include the overhead costs of purchasing required for the opening and cancellation of the associated PO line. If a supplier already made costs, for instance the process at the supplier was already started or the goods are already shipped, the supplier generally does not agree with cancellation of the PO line without payment of the obligation. The purchaser will then ask the supplier to halt their processes and push-out delivery of the part. In the mean-time they will

continue negotiation with the supplier. There are in general three possible outcomes in this case. It might be possible that the demand in the system may come back for the item, it thus no longer needs cancellation and the supplier can proceed with shipment of the good. If the cancellation continues to be needed, the buyer might decide to cancel the PO and pay the obligation or the buyer might decide to bring in the good. In both cases there might be discounts on the goods, depending on the negotiation process. If a good is brought in it will be excess inventory and at risk to become obsolete inventory for which inventory holding costs will be involved.

2.1.2. Costs due to the cancellation of POs that were opened in previous years

Figure 5 shows the paid amount in terms of invoices and the overhead costs due to the process of handling the cancellations in the purchasing department. It shows the costs due to POs that were opened in 2016, 2017 and 2018 that have been cancelled so far as of April 23, 2019. There is also an amount still requiring cancellation of POs that may add to the costs displayed here, this is discussed in Section 2.1.3. Note that there are also costs made for the goods which needed to be cancelled but which are delivered. Data on the amount and value of goods received that should have been cancelled is not available in Besi APac, but these would add to the total costs because they risk becoming excess and possibly obsolete inventory.

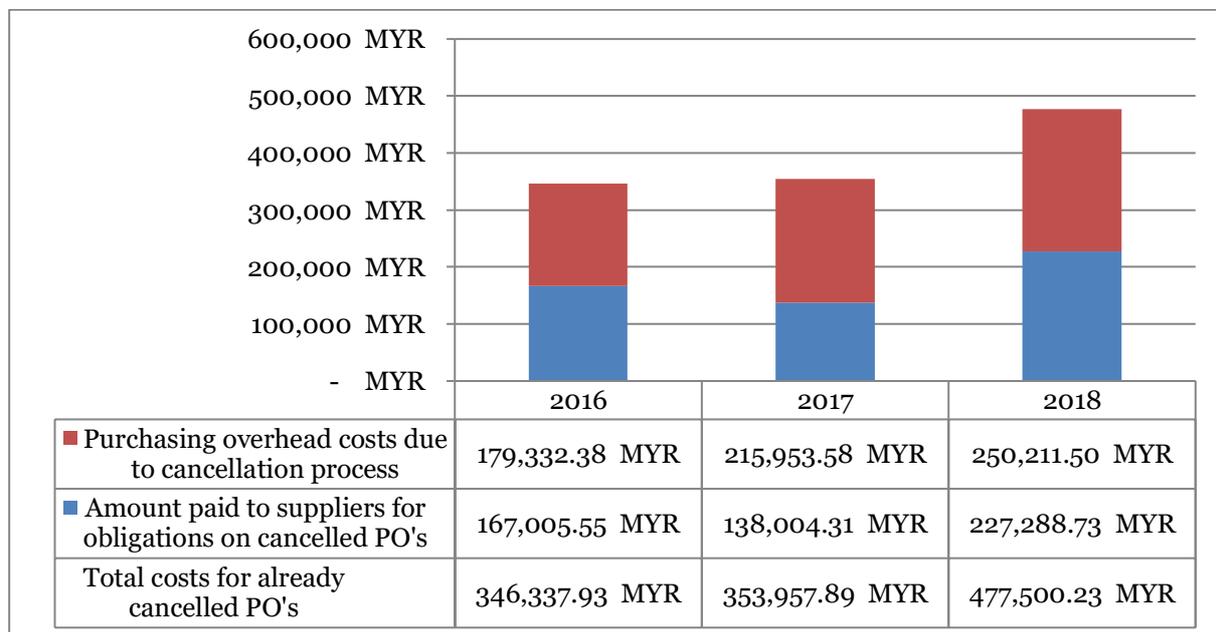


Figure 5. Costs due to obligations on cancelled POs and overhead costs associated with the process of cancellations handling in the purchasing department. Only the costs made for POs opened in 2016, 2017 and 2018 and that have already been cancelled are shown.

It can be seen from Figure 5 that overhead costs of the purchasing department due to the time spent on the process of handling cancellation has a bigger impact on total cost than the amount that had to be paid to suppliers. This can be explained by the fact that purchasers spend their time largely on three activities: sending out POs to suppliers based on demand in the system, rescheduling delivery dates for POs when the need date for goods in the system changes, and

cancellation of POs that no longer have a demand. As the cancellations are on average 13% of total open PO lines, an estimation of the part of the purchasing department’s overhead costs due to the cancellation process can be made assuming that on average the same amount of time is used by purchasers for each handling of a PO, be it a release, reschedule or cancellation activity. This is a conservative estimation because it is likely the cancellation of a PO takes more time than releasing one. As well only the payroll expenses are used as part of the overhead cost. The costs of overhead due to the cancellation process is then estimated by equation 1, in which the percentage of cancelled POs of all opened POs in a year is multiplied by the payroll expenses (found in appendix D.) and multiplied by two because every cancelled PO was also opened before.

$$\text{Estimation purchasing overhead cost due to cancellation process} = \text{Payroll expenses purchasing} \times \frac{\text{no.of cancellation POs}}{\text{total POs released}} \times 2 \quad (1)$$

2.1.3. PO lines opened in 2016, 2017 and 2018 which still require cancellation

As of April 23, there are still 1355 PO lines awaiting cancellation of the POs that where opened between 2016 and 2018, resulting in a total open value of 4.8 million MYR for POs of these years alone, see Figure 6. These PO lines are at risk to be added to the total amount of obligation for cancelled POs shown in Figure 6, or they will become excess inventory if they are not cancelled. They have been open for a significant time already and cancellation might not be possible without paying part of the PO value. As they are aging POs it is likely that a large part will not be able to be cancelled without paying an obligation, and as well negotiation on these PO lines will involve overhead costs of the purchasing department.

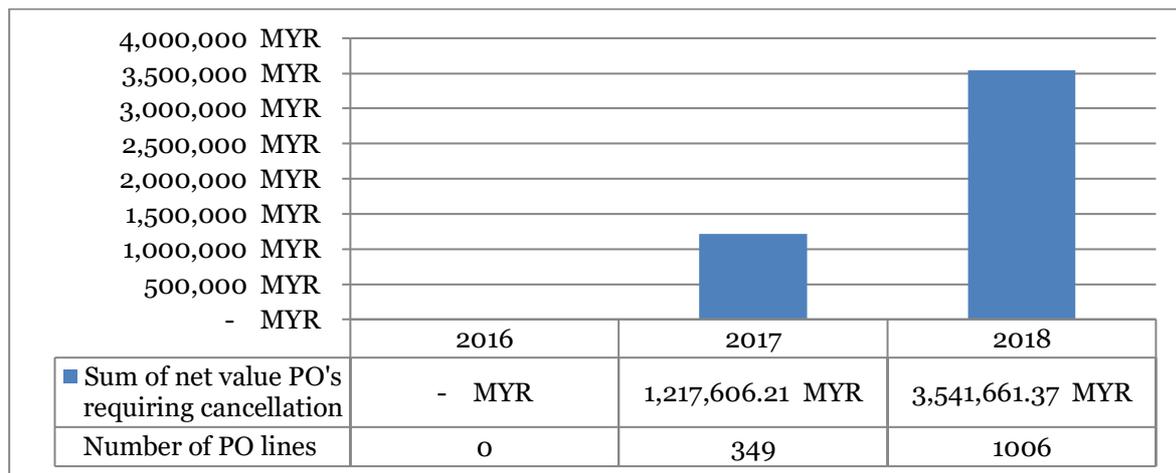


Figure 6. Value of POs opened in 2016, 2017 and 2018 that have already been cancelled and the value of POs opened in those years that are still required to be cancelled on April 23 of 2019.

All costs that are mentioned above represent losses for Besi. Besi has a flexible cancellation policy for its customers which means costs due to cancellation of sales orders by the customer cannot be reclaimed. However, costs of cancelled POs are sometimes charged into the costs of



a machine that is delivered but for which the configuration has changed. It is currently not tracked inside Besi how high these costs charged to the machines are.

In the previous sections it has been found that the obligation costs represent a small part of the total value of POs which need to be cancelled. There thus seems to be a large part of POs required to cancel which are not cancelled or are cancelled without or only with minimum obligation. However, the mentioned costs are only the costs on POs that have been assigned to the provision specifically for PO cancellations. Costs in Besi are currently not sufficiently tracked to obtain a clear picture of overall costs, but it is clear that an obligation of 14% of the open value of POs presents a risk to Besi and thus research is required for Besi to be able to improve its processes such that this open value can be reduced and in effect reduce the risk associated with these open obligations and as well to be able to reduce the operational expenses due to processing of purchase order cancellations.

2.2. Problem statement

Besi APac has an average value of 9.8 million MYR in open POs which need cancellation according to the internally used SAP system. The value represents 10-14% of the total open PO value which are committed to the supplier that the system indicates is not needed. This presents a large risk for Besi as the total amount is committed to the supplier and might be invoiced. Aside from the risk, cancellations result in the following costs:

1. The high number of cancellations results in an estimated 215 thousand MYR in yearly overhead costs in the purchasing department due to time spent on processing these cancellation PO lines. They are also likely to result in reduced service levels from suppliers in terms of delivery lead times and price levels.
2. Cancellation of POs can result in cancellation fees from the supplier, resulting in the following costs:
 - Costs which are due to POs that are cancelled with obligations that could not be declared from the customer: 177 thousand MYR in invoices yearly on average.
 - There is an open value of 4.8 million MYR requiring cancellation for POs which have been opened in the previous 3 years. These POs can potentially be invoiced by suppliers in the future.

The mentioned costs are considered a waste as they do not contribute to an increased output but rather decrease the likelihood that a profit margin of 53-57% can be maintained for Besi N.V. in times of low demand in the semiconductor market. The reduced service levels from suppliers impacts the other strategic objective of Besi, which is that they want to increase their scalability of operations.

2.3. System description

In Figure 7, the subject of study is depicted using a system description (Kim, 1999). All processes within the blue square are considered inside the system under consideration in this study. Only processes in the planning and material management departments are considered. These processes convert the inputs coming from Besi's Business Partners (BBP) ultimately into the output of POs to the supplier. The inputs coming from the BBP consist of information on machine orders, basic machine and Customer Specific Requirements (CSR) forecasts come from the BBP's sales team, and notices of engineering changes that come in from the engineering team.

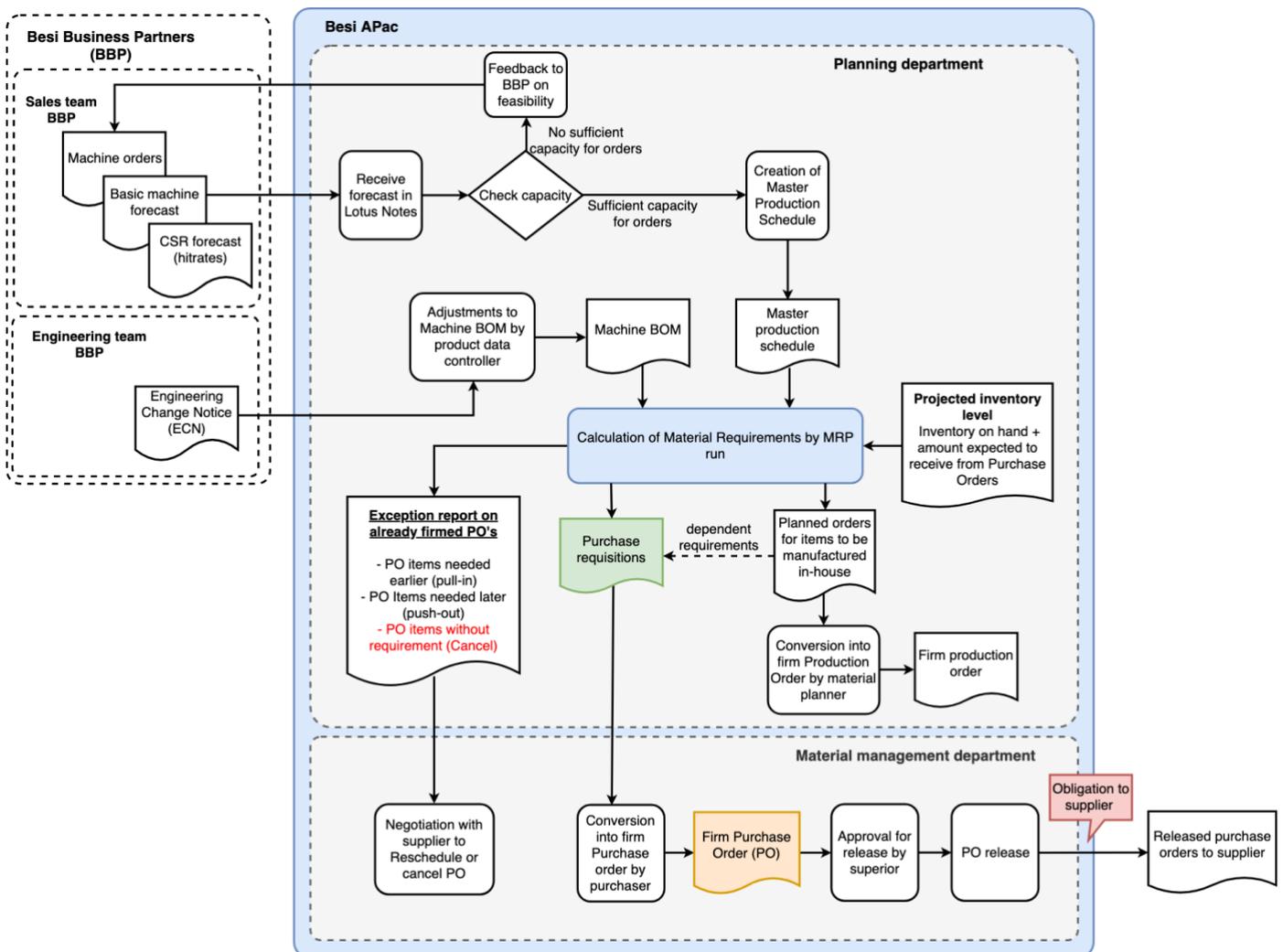


Figure 7. System description. Sales orders come in from Besi APac's affiliates in the Netherlands, Austria and Switzerland, together referred to as Besi Business Partners (BBP). The process the orders go through in the planning and purchasing departments of Besi APac are shown in this picture, until the point of purchase orders that are released to the supplier.

Crucial in the process is how the material requirements are calculated using the internally used SAP system. The SAP system does this based on the Material Requirements Planning (MRP) algorithm. MRP can be considered to be an optimal control problem that aims to minimize

material and product levels in store, while ensuring materials are available for production and products are available for the delivery to customers on time. Inputs of the system are the Machine BOM, the master production schedule and the projected inventory levels. The outputs are the planned orders for items that can be manufactured in-house and purchase requisitions for items that have to be sourced externally. Both should be seen as recommendations by the system which only become secured (firm) when it is manually converted into a production order by the material planner or purchase order by a purchaser. Purchase requisitions and planned orders disappear or change automatically if there is no need for them after an MRP run or the need-by-date changes. However, firm production or purchase orders can only be deleted or rescheduled manually. For this purpose, SAP issues an exception report with three types of recommendations: PO items that have to be brought in earlier (“Pull-in”), PO items that are needed later (“Push-out”) and PO items that are not needed anymore at all (“Cancel”). The focus in this project is on the PO items that are marked for cancellation. All POs that are marked to be cancelled by SAP require processing time because they have to be deleted manually. If these POs are already released to the supplier, there exists a formal obligation to take in the item and they can only be deleted after agreement of the supplier.

2.4. What are the possible causes leading to the problem?

In this section the possible causes leading to the problem are identified, using both information from within the company and what can be found in literature. A wide variety of literature indicates the problem of a high amount of POs to be rescheduled and cancelled to be a result of a phenomenon known as “MRP nervousness” (Mather, 1975). In Besi APac, all supply requirements are calculated by MRP based on the demand and available quantity of items, as has been illustrated in the system description. Variability in the input to this MRP system can result in frequent “jerking around” of purchase orders as the MRP system becomes unstable. One result is a high number of purchase orders that are being marked for cancellation, which can change considerably from day to day. The factors identified in literature are diverse, but most frequently mentioned are factors correlated with the problem of nervousness are the uncertainty in demand, errors in forecasting (Ho and Ireland, 1998) (Ritzman and King, 1993), safety stock and lot-sizing decisions (Blackburn, Kropp and Millen, 1985), rescheduling frequency and planning horizons (Yeung, Wong and Ma, 1998).

(Koh, Saad and Jones, 2002) consider a much wider window of factors that can cause uncertainties in MRP system, where they use a system-theoretic view to make a distinction between *input* uncertainties and *process* uncertainties. This research aims to apply a similar approach, identifying causal factors of POs needing cancellation as originating from outside the system as well as factors within the internal processes. Additionally, the effect of processes after the appearance of a cancellation message in the system on the total open value of cancellation POs is considered, as PO lines sitting in the system for a long time may cause the value of open POs to be cancelled to grow over time (Figure 6 showed that there is a large value of POs require cancellation remaining open in the system for longer than a year).

The total set of factors that have been identified as influencing the problem of the high value and number of PO lines to be cancelled at Besi APac are illustrated by the use of an Ishikawa

diagram (Figure 8). Qualitative data to fill in the Ishikawa diagram is gathered through Michael Wong, business analyst at Besi APac, and through structured interviews with purchasers and meetings with section heads (DiCicco-Bloom and Crabtree, 2006), see Appendix B. Michael Wong is in charge of tracking the number, type and causes of rescheduled POs. He sends out a daily report, in which the cause of each PO cancellation is mentioned. The most common causes are classified into 11 different categories, which can be found in Appendix A. In Figure 8 all the suspected causes that have been derived from interviews, the daily material management report and literature are shown. They have been divided into four categories: causes related to the method, causes related to the machine (which is interpreted here as the SAP system that is used for ERP purposes inside Besi), causes related to manpower and causes that originate from the environment.

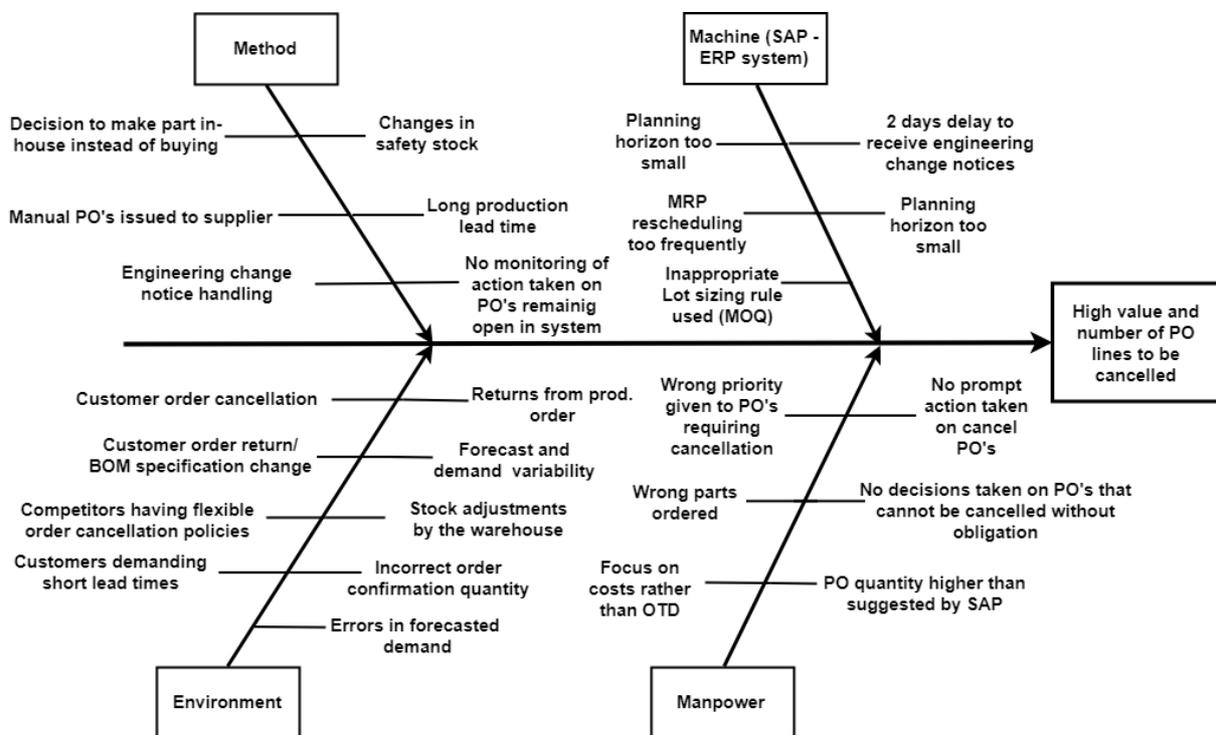


Figure 8. The Ishikawa diagram shows the probable causes leading to a high value and number of PO lines to be cancelled at Besi APac, divided into four categories of method, machine, environment and manpower.



2.5. Stakeholder analysis

A variety of definitions for stakeholders exist where the broad definition of (Freeman, 1984) is used. The power-interest framework (Ackermann and Eden, 2011) is applied here to differentiate between the project's stakeholders.

CEO Besl N.V. and shareholders: high power, medium interest

The aim of the CEO is to satisfy the shareholders. Shareholders have high power because the company depends on their resources for survival. The purchase cancellations impact the total costs of Besl's operations and thus the revenue. However it is only a small part of total costs of Besl N.V. so the interest in the project is considered to be medium.

Besl Business partners: high power, low interest

The "Besl business partners" (BBP) is the term used within Besl to denote all the locations of Besl in Europe. At the BBP, research and development takes place for each of the product lines in Besl and here the sales department is located. The BBP share the forecasts and machine orders with Besl APac. Their power is high, because they decide which machines are going to be made at Besl APac and in which configuration. However, the interest of the BBP's to solve the issue with PO cancellations that occurs at Besl APac is rather low as they are not directly impacted by the resulting costs.

Suppliers: high power, medium interest

Suppliers have an interest in a reduction of PO cancellations coming from Besl APac because cancellations of POs results in fewer goods sold. As well, suppliers have inventory holding costs for items that Besl would like them to hold and associated risks in the case Besl goes bankrupt. Suppliers generally have higher revenues than Besl APac and generally have many customers. This means that their stake in the problem is not high. It does mean that they have a high power position in negotiations.

Production department: low power, low interest

The production department is interested in the on-time delivery of goods and therefore a better material management process in general. They may play a role in causing cancellations, however an interest in the reduction of them is considered to be low.

Warehouse department: low power, low interest

The warehouse has no direct interest in reducing PO cancellations. They are taken into account however as the method of stock tracking is considered a possible cause to PO cancellations.

3. Research design

The research design is defined in this section by a research goal, research questions, scope and method. The research method that is followed is the problem solving cycle of Van Aken (Van Aken and Berends, 2018), with a strong emphasis on the diagnostic phase as it is currently not clear what the root-causes of the problem Besi is facing are. The research is practically oriented: it is focused on one case, which is improvement of the purchasing process at Besi APac. Knowledge obtained from this case-study may be used to improve the purchasing process in the other manufacturing location of Besi in China as well, and might prove useful for other companies within the semi-conductor industry that use SAP to control their material requirement planning.

3.1. Research goal and questions

The research goal for the diagnostic phase of the project is to identify the root-causes that contribute the most to the high open value and number of purchase order (PO) lines that are marked for cancellation at Besi APac. In Section 0, a design is proposed based on the factors that are shown to have the highest impact. The main research question of this project is as follows:

“What are the factors causing the high open value and number of PO lines marked for cancellation at Besi APac?”

As the open value and number of POs being marked for cancellation at any time is influenced both by new POs that need to be cancelled as well as by how many of these POs that need cancellation are actually cancelled, the analysis is divided into two stages, each having its own research question and sub-questions:

1. What is the main root-cause leading to new PO lines which are marked for cancellation by SAP?
 - 1.1. What is the impact of each causal factor on the total value of new PO lines that are marked for cancellation?
 - 1.2. What is the impact of each causal factor on the number of new PO lines that are marked for cancellation?
 - 1.3. What is the top causal factor based on both the measures of value and the number of lines and the level of controllability of the factor?
 - 1.4. What are the root-causes leading to the top causal factor in terms of both value and lines?
2. Why do POs that are marked for cancellation stay open in the system for longer than half a year?
 - 2.1. How prompt is action taken when a new PO is marked for cancellation?
 - 2.2. How is priority assigned to the POs that are marked for cancellation?
 - 2.3. What is the process of monitoring the negotiation status of POs that are marked for cancellation?



- 2.4. How soon can POs that cannot be cancelled without obligation be charged out and cancelled?

3.2. Scope

The research covers the orders that are placed from within Besl APac and only those which are marked for cancellation. Both the direct orders for Die Attach (DA) and for the Packaging and Plating (PP) machines and indirect orders, which are orders that are not directly linked to one of the product families, are included in the data that is analyzed. The research excludes orders placed to refill floor stock and orders that are placed from other locations of Besl, such as Besl Leshan and Besl Singapore. All the purchasing sections (Vendor Parts (VP), Complete Module Outsource (CMO) and Fabrication Parts (FP)) are taken into account for analysis. Furthermore, the focus of the research and subsequent design is on the root-causes which have been found to contribute the most to the value and number of POs marked for cancellation, which is reflected in the research questions.

3.3. Method and tools

The method followed and tools that are used in the research are separately discussed for the two stages of analysis that are performed:

Analysis stage 1: root-causes of new POs being marked for cancellation.

The following steps are taken in stage 1 of the analysis:

1. Data on the causes of a high number and value of PO cancellations (Sub-questions 1 and 2) is retrieved from the daily material management reports. The daily report is generated by the business analyst of Besl APac. Causes are tracked for each instance of PO that needs to be cancelled in this report. For this research the data contained in all reports generated between October 1, 2018 and March 30, 2019 (6 months) is gathered and analyzed.
2. The data from the material management reports is lumped together into a set of 42 categories (See Appendix B.). Two separate Pareto analyses (Craft and Leake, 2002) are performed, one based on the number of PO lines and one based on the value.
3. To determine the top causal factor based on the result of the two Pareto analyses, causal factors are divided into external and internal process related causes. Recommendations from literature are used to support the choice that is made for the top causal factor that is addressed in the root-cause analysis in Section 0.
4. 5-Why analysis (Serrat, 2017) is performed to identify root-causes of the top causal factor that has been identified. For each purchasing section, data of the top 40 PO lines in terms of their value is shared with the respective section head. The root-causes are identified based on iterative questioning of the section heads (asking why 5 times) and by going through history of transactions and comments made by buyers in SAP.



Analysis stage 2: root-causes for POs marked for cancellation remaining open in the system for longer than 5 days.

The information for the second stage of analysis is gathered via interviews with people in the purchasing department. Promptness of calculation will be measured by the success rate of cancellation for POs that were issued within the last 5 days and have a cancellation message. Purchasers are asked how they assign priority POs that need to be cancelled, and what the procedures and requirements are before a PO can be cancelled. As well, they will be asked what reasons they have for POs not being cancelled immediately. Section heads will be asked how the status of POs that should be cancelled is monitored and how they ensure action is being undertaken on them.

4. Analysis

4.1. Root-causes of new purchase orders being marked for cancellation

In this section, the research question for the first stage of analysis is answered. This is done by analyzing data from the daily reports that are made in Besi APac. Categorizations are appointed to each case. Data is gathered for 6 months, from October 1 2018 until March 30, 2019. The total value and number of lines and the daily average in this period is summarized in Table 1.

Category	Total	Daily average
Value of new POs marked for cancellation in period	26,063,327 MYR	236,940 MYR
Number of lines of new POs marked for cancellation in period	3692 lines	34 lines

Table 1. Overview of total and average values and number of lines in the data set, covering all the daily new POs marked for cancellation in the period from October 1 2018 until March 30, 2019.

4.1.1. Pareto analysis based on the total value of cancellation POs

In this section, sub-question 1.1 is answered. In Figure 9, a Pareto chart is drawn for the total value of cancellation POs in MYR for each cause category. In total 42 categories of causes have been formed, but only the top 15 categories have been included in the graph as the lower categories make up less than 1% of the total value. It can be seen that in terms of value, the manual PO to supplier, forecast change and demand change are the top 3 causes, adding up to 56% of the total cancellation value in the period of October 1 2018 until March 30 2019.

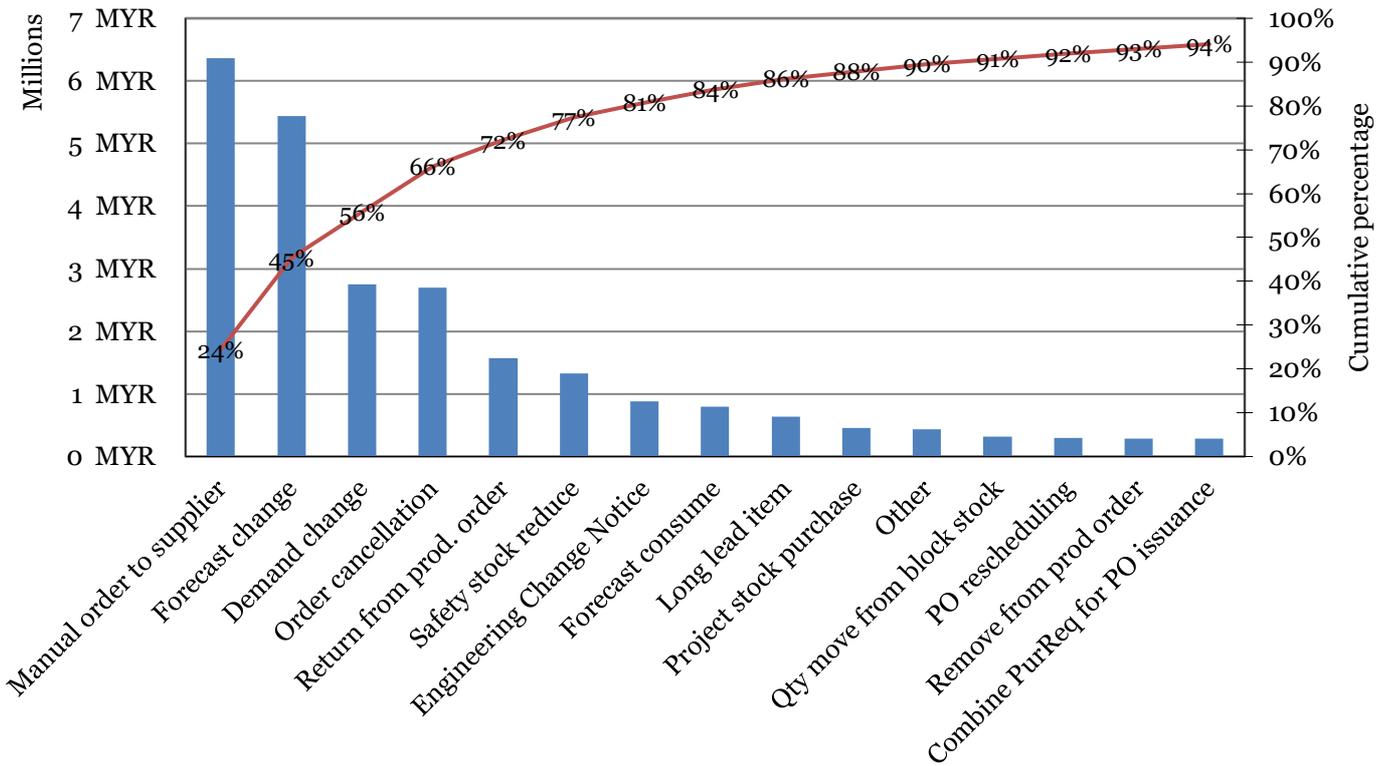


Figure 9. Pareto chart based on the grand total value of POs needing cancellations in MYR by cause, for the period of October 1, 2018 until March 30, 2019. Only the top 15 categories out of 43 categories have been included in the graph.

4.1.2. Pareto analysis based on the number of cancellation POs

In this section, sub-question 1.2 is answered. In Figure 10, a Pareto chart is drawn based on the total number of lines by cause category. Here, it can be seen that the top three causes are the forecast changes, demand changes and reductions in safety stock, together contributing to 52% of the total number of cancellation lines.

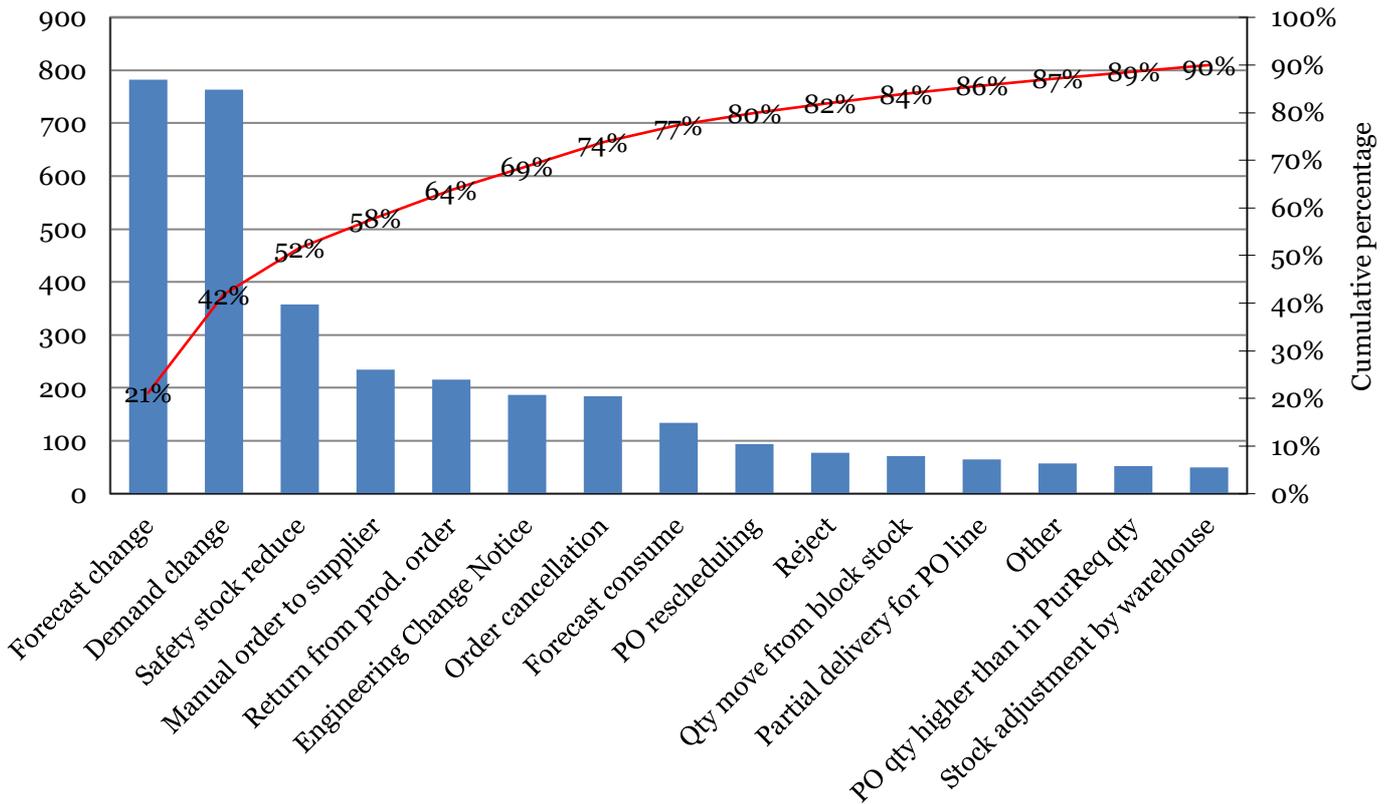


Figure 10. Pareto chart based on the total number of cancellation PO lines by cause category for the period of October 1 2018 until March 30 2019. Only the top 15 categories out of 43 categories have been included in the graph.

4.1.3. Combination of both measures and selection of the top causal factor to be investigated

In this section, sub-question 1.3 is answered. The results of both the Pareto Analyses in Section 0 and Section 4.1.2 are combined and a selection of the top causal factor based on its contribution to the both the total value and number of new PO lines being marked for cancellation and the level of controllability is made. The column on the left of Table 2 shows the 15 causes that result in the highest number of cancellation POs in descending order, whereas the column on the right of Table 2 shows the 15 causes that result in the highest value of cancellation POs. A distinction is made between external causes (outside of the system that is considered) and internal causes. Causes that are marked with red color have an external cause and the causes that are related to internal processes are marked with green color.

Causal factors no. of lines	Perce ntage of all cancel ation lines	Causal factors values	Perce ntage of total PO value
Forecast change	21%	Manual order to supplier	24%
Demand change	21%	Forecast change	21%
Safety stock reduce	10%	Demand change	11%
Manual order to supplier	6%	Order cancellation	10%
Return from production order	6%	Return from production order	6%
Engineering change notice	5%	Safety stock reduce	5%
Order cancellation	5%	Engineering Change Notice	3%
Forecast consume	4%	Forecast consume	3%
PO rescheduling	3%	Long lead item	2%
Reject	2%	Project stock purchase	2%
Quantity move from block stock	2%	Other	2%
Partial delivery for PO line	2%	Quantity move from block stock	1%
Other	2%	PO rescheduling	1%
PO quantity higher than in Purchase Requisition quantity	1%	Remove from production order	1%
Stock adjustment by warehouse	1%	Combine Purchase Requisition for PO issuance	1%

Table 2. Comparison of the measures of value and number of PO lines. The column on the left shows the 15 most frequently occurring causes of cancellation PO lines in descending order. The column on the right shows the 15 causes that result in the highest value of cancellation POs. Causes that are marked with red color are external process related, and the ones marked with green causes are related to internal processes.

Figure 11 below shows the ratio of the impacts of external and internal factors on both the total value of PO cancellations in the data set and Figure 12 shows the ratio based on the number of lines.

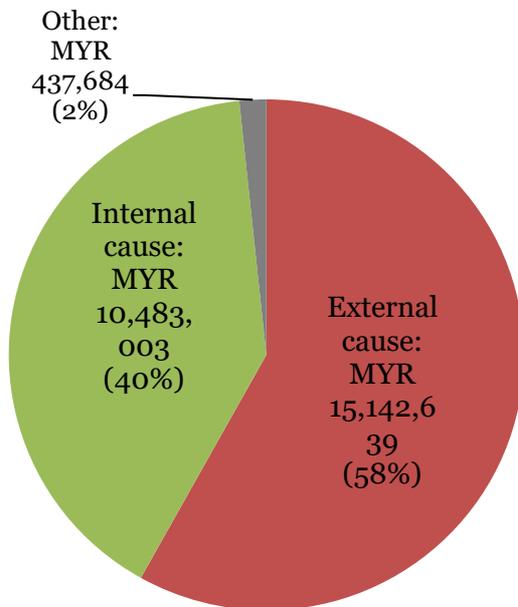


Figure 11. Breakdown of cancellation POs into internal and external causes, by value.

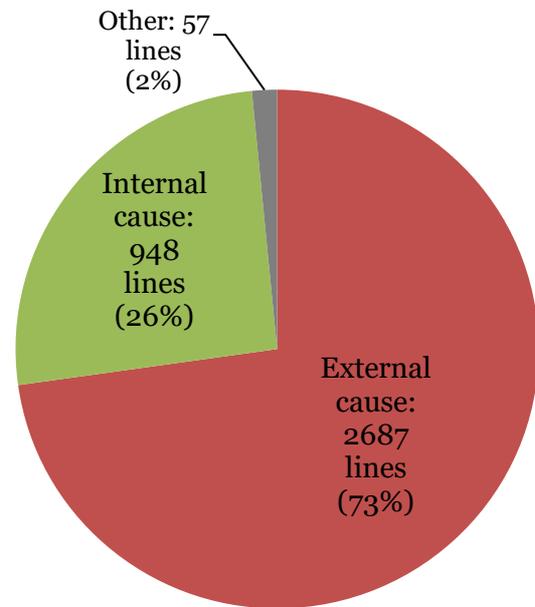


Figure 12. Breakdown of cancellation POs into internal and external causes, by the number of lines.

The internal processes are considered to be controllable in the sense that changes in the internal process can reduce the root-cause of the factor's occurrence. External factors are not controllable directly, but buffering and dampening strategies can be applied to reduce their impact on cancellation. Examples are improved lot-sizing and safety stock management as described in (Blackburn, Kropp and Millen, 1985) or hedging/overplanning as described by (Koh, Saad and Jones, 2002). (Mather, 1975) however recommends focusing on internal process related factors before buffering and dampening measures are considered. Although the external factors contribute to both the largest value and number of PO lines to be cancelled, it is therefore chosen to focus on the internal process related factors in this project as they still contribute to a large part especially in terms of the value.

(Mather, 1975) considers as internal process related factors to be changes in the internal demand and supply of materials, examples being inventory changes, engineering changes, record errors and unplanned transactions. These internal factors induce delay in the sharing of information of supply and demand within the manufacturing cycle and in this way can result in more cancellations, or they may induce incorrect representation of the actual supply and demand. Engineering changes are considered to be an external cause in the case of Besl APac, as the engineering of machines happens in Europe. (Mather, 1975) concluded that only after



the elimination of internal process uncertainties, buffering and dampening approaches to external demand such as lot-sizing and safety stocks should be considered. Buffering and damping approaches have the effect of masking the internal process uncertainties and result in excess inventory levels and work in progress (WIP).

The causal factor “Manual order to supplier” has the highest impact both in terms of number of lines and the value of the internal process related causal factors. Therefore, the root-cause analysis performed in Section 4.1.4 focusses on the root-causes of manual orders. By removing this factor, 24% of total value of new POs being marked for cancellation and a reduction of 6% in the amount of new lines marked for cancellation can be obtained.

4.1.4. Root-cause analysis into causal factor “manual order to supplier”

In this section, sub-question 1.4 is answered for the causal factor “manual order to supplier”. To illustrate how a manual order can lead to a cancellation message in SAP, the MRP process with its direct inputs and outputs is shown in Figure 11. The inputs of the MRP calculation are the gross material requirements, which come from the master production schedule (which is made based on the forecasted demand and customer orders of machines) and the current BOM of materials for each machine. The net requirements are calculated by subtracting the projected future inventory level, which consists of the current stock on hand and the total amount that currently is in the purchase requisitions, planned orders, firmed purchase orders and firmed production orders. As an output, the MRP calculation presents the requirements in the form of new purchase requisitions and planned orders. Purchase requisitions and planned orders from the previous MRP run that are no longer required and have not yet been converted into a firm order are deleted automatically. However, if they have been converted already and there is no longer a requirement, SAP will ask for manual cancellation of these items by marking it for cancellation in the exception report.

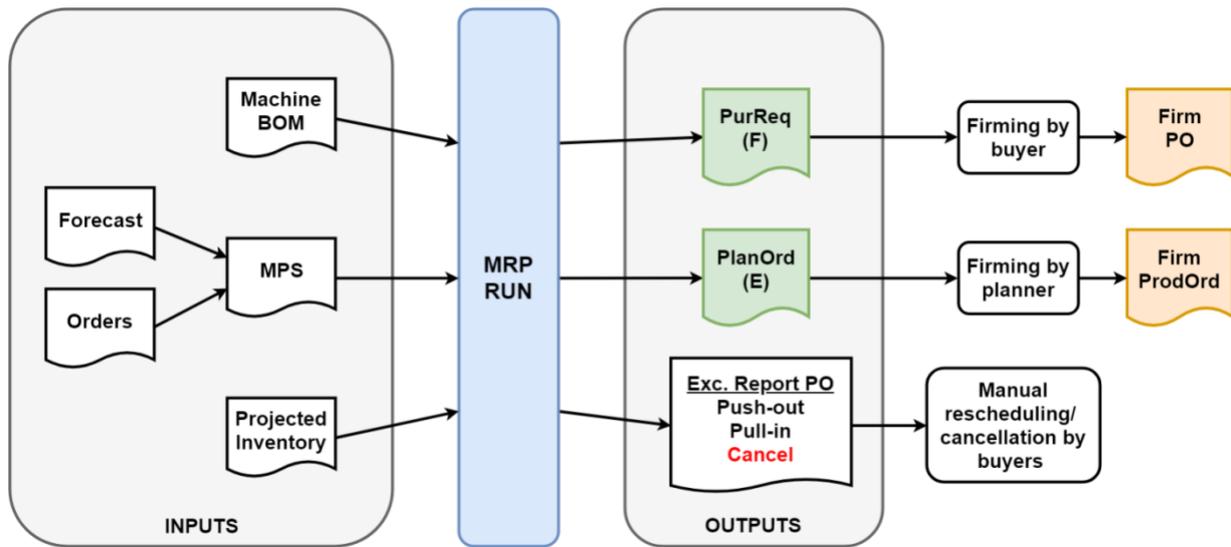


Figure 11. The MRP Run with its inputs and outputs is shown here, which is a subsystem of the overall system description (Figure 7). Direct inputs are the Bill of Materials (BOM), Master production schedule (MPS) and the projected inventory. Direct outputs are the Purchase Requisitions (PurReq) for outsource (procurement type F in SAP) and Planned Orders (PlanOrd) for in-house production (procurement type E).

Normally, the purchasers and material planners create firmed purchase orders and production orders only based on the net requirements that are suggested by SAP after a MRP run. However, as it has appeared from the analysis above, manual orders are being created, which means any manual orders to procure material outside of the recommendations in the Purchase Requisitions and Planned Orders generated by the MRP run.

The majority of the manual orders in the data set have been found to be released by the purchasers in the Vendor Parts and Complete Module Outsource purchasing sections. The value and amount of manual orders released by purchasers from the Fabrication Parts purchasing section are negligible as can be seen in Figure 14 and Figure 15.

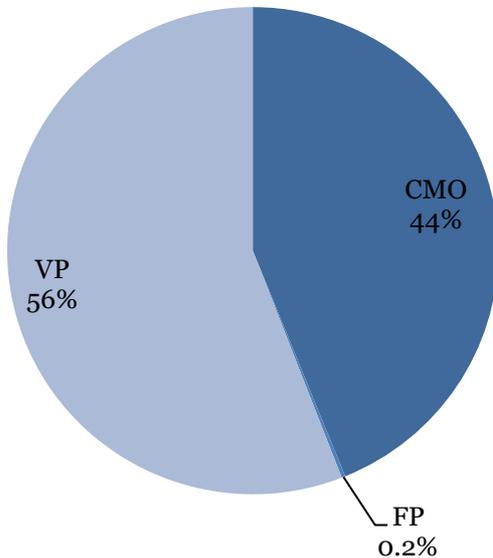


Figure 14. Percentage of manual orders in each purchasing section by the total value

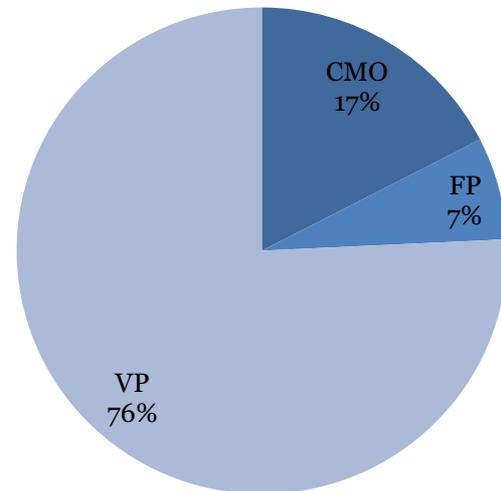


Figure 15. percentage of manual orders in each purchasing section by the number of lines

5-why analysis (Serrat, 2017) has been conducted to understand the root-causes of the manual orders. For this purpose, the top 40 PO lines in terms of their value are shared with the responsible purchasing sections from which the POs were issued. The full 5-why analysis is shown in Appendix E. It resulted from interviews with the section heads of VP and CMO, the manager of material planning and the person responsible for maintenance of the SAP system in Besi APac.

The first result from the 5-why analysis was that there are three types of manual orders that can be distinguished:

- (1) A purchase requisition is created manually.
- (2) A purchase order is created manually while SAP has no purchase requisition for the item.
- (3) A planned order for in-house production is converted into a manual purchase requisition.

In the first case, the manually created purchase requisition will automatically disappear in a next MRP run if it has not yet been converted to a firm purchase order. In the second case, the purchase order is already firm and as an effect SAP will show an exception message asking for cancellation of the order after the next MRP run. In the third case this will result in a cancellation message for a purchase order (if the purchase requisition has been firm into a purchase order) but will also result in a cancellation message for all the purchase orders for materials that were required for in-house production under the planned order that is deleted.

These purchase orders represent the *dependent requirements* of the planned order. Figure 12 shows the points in the subsystem where the three types of manual orders are being made.

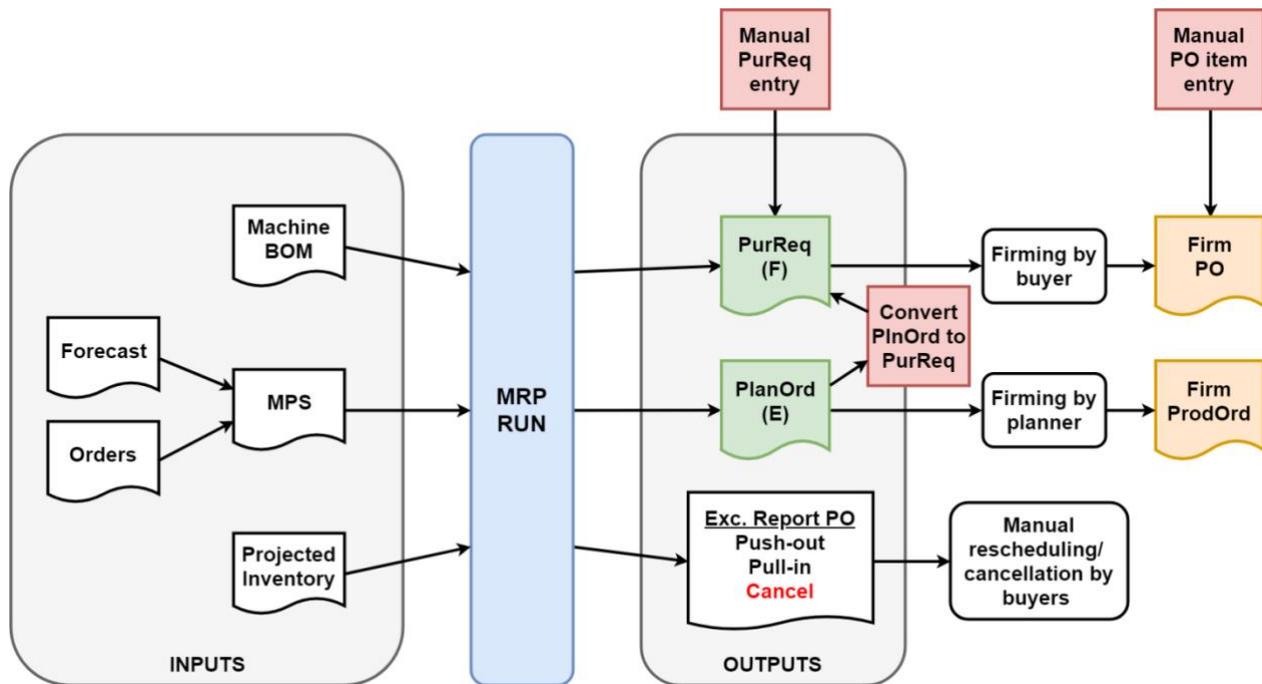


Figure 12. Figure showing the inputs and outputs of the MRP calculation, and the three different types of manual orders that can be distinguished.

It has been found that the most common reason for manual PO item entry is that either there is urgent support needed, there is a Pre-order request by planning or there is a technical limitation in SAP so that a manual demand or manual purchase requisition cannot be created. Urgent support being needed is often because a supplier may be unable to meet the requirements, which can mean for example that they are unable to meet the date the material is needed in production, or the item may not meet quality standards. In this case a new PO is being placed to a different supplier but when the old PO is not deleted, the system sees this as an excess supply and will trigger a cancellation message. Another reason is that planning sees sales order coming which however is not reflected in SAP yet. When the item is needed urgently, planning sometimes request purchasers to purchase the material via a manual purchase order. A third reason for the entry of manual POs is the special case when a supplier asks Besi to consign material from a different supplier. This means Besi purchases the material from supplier A so that it can be used in production at supplier B that supplier B is going to deliver to Besi. It is in this case not possible to create a demand in SAP for this special case due to technical constraints.

For manual purchase orders being entered, one main reason has been found. This reason is the call-off of expired quantity contracts. A Quantity Contract (QC) is a deal made with a supplier to purchase a certain quantity of material in a given time period. When the quantity contract

expires, the remaining quantity has to be brought in even when the demand turns out to be lower than expected.

In the case where planned orders are converted to purchase requisitions, the main underlying reason has been found to be a need for urgent support. A supplier or another location of Besi N.V. may hold the module that is normally made in-house in their inventory, so planning makes the decision to convert an in-house planned production order to a purchase requisition, for which the internal term is “purchase at E level”. This results in not only a notification to cancel the purchase requisition, but also will result in cancellation of all the dependent child items of the planned order for which POs may already have been issued.

Table 3 summarizes the root causes that have been identified and the type of manual orders that are used.

Root-cause	Type of manual order
Call-off expired QC	Manual Purchase Requisition
Purchase at E level	Conversion of planned order to purchase requisition
Pre-order request	Manual Purchase Order
Consign material from supplier A to supplier B	Manual Purchase Order
Supplier unable to meet requirements, new Purchase Order placed to different supplier	Manual Purchase Order

Table 3. Summary of root-causes identified and the way in which they are issued.

Figure 13 shows the percentage of each root-cause and their relation to the total value of the manual orders. It can be seen that call-off expired QC, Purchases at E level and Pre-order request contribute the most to the open obligation value of POs marked for cancellation. From Figure 14 it can be seen that these three causes also contribute to the highest number of PO lines marked for cancellation.

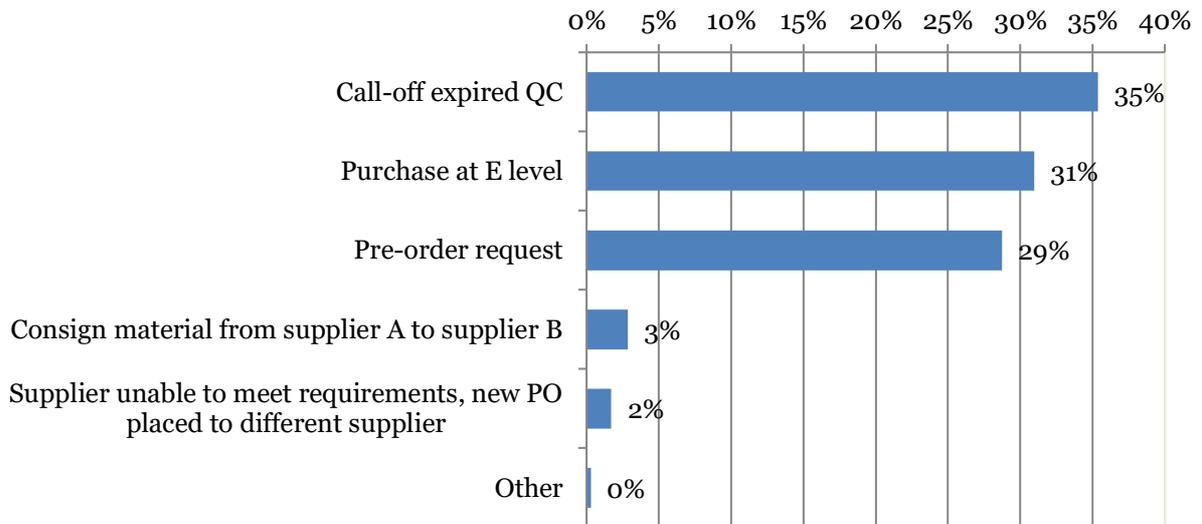


Figure 13. Percentage of each root-cause in relation to the total value of manual orders.

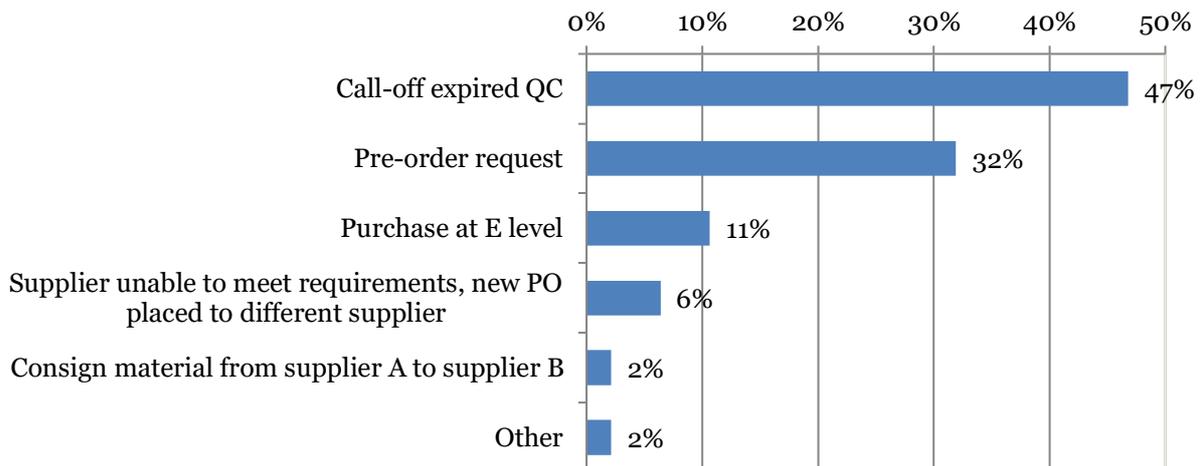


Figure 14. Percentage of each root-cause in relation to the total number of manual orders.

The case of purchases being made at E level is interesting as they can result in the increase of three other causal factors for PO cancellations, which are displayed in Figure 15. These values are low compared to the total cancellation value (in total 2.07%), however it should be noticed that these are only the PO lines for which it was possible to identify the root-cause. It is suspected that a large value of the PO lines under the category “demand change” which contributes to 21% of the total value (Figure 9) and lines (Figure 10) marked for cancellation may in fact be caused by manual orders. This illustrates how manual orders can result in unwanted outcomes which may not be visible and how it confuses the MRP run in calculating actual required supply.

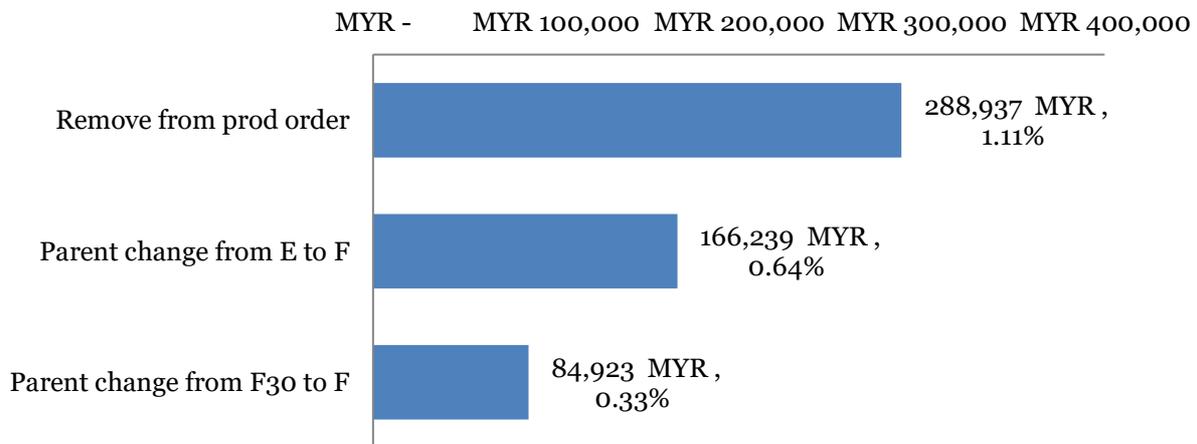


Figure 15. Causal factors in the data set that are a result of the root-cause "purchases at E level", their value and percentage of the total cancellation value.

4.2. Root-causes for purchase orders marked for cancellation remaining open in the system

In this section, the research question for the second stage of analysis is answered. In Section 2.1.3, Figure 6, it has been shown that there was a value of 1.2 million MYR of POs opened in 2017 and 3.5 million MYR opened in 2018 which still require cancellation as of 23th of April, 2019.

In Figure 12, the different steps that are possible after a PO needs to be cancelled are again shown. Every day, each of the purchasers gets a list of all POs that they have opened but that need to be cancelled, which was 2367 lines long on the 23th of April and is on average 9-15% of all open PO lines. With 21 purchasers in the department, this means each purchaser has on average 113 lines daily open POs that need to be cancelled. Buyers therefore have to assign priority to which lines they take action on first. How they assign this priority is discussed in Section 4.2.2. For the lines they assign priority to, purchasers start negotiating with the Supplier. As shown in Section 2.1.1, this process can have the two main outcomes:

1. The PO can be cancelled immediately without payment for the items.
2. The supplier does not agree with cancellation and items should be paid.

Naturally, the second case has the most impact on the total costs. In the MM daily report, a status indicator is included for all POs that have been negotiated on already and for which the supplier does not agree to cancel the PO without obligation. These are currently assigned the status "unable to cancel". For 23th of April, the value of PO with the status "unable to cancel without obligation" has accumulated to 2,441,643 MYR, which is 32.61% of the total PO marked for cancellation, see Figure 16.

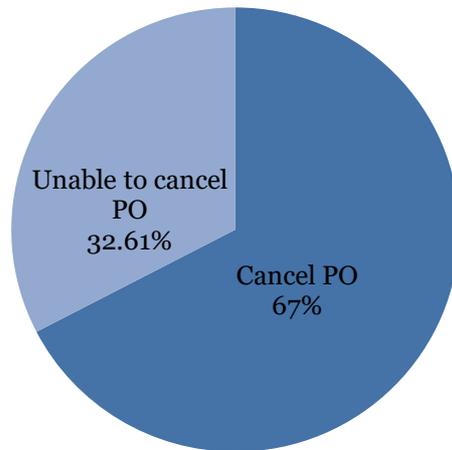


Figure 16. Ratio of POs that were marked as “Unable to cancel” by postponing the delivery date to 25th of December or the 30th of June. Data extracted on 23th of April, 2019.

The ratio of POs unable to cancel naturally grows based on how long ago the PO was opened in previous years is shown in Figure 17.

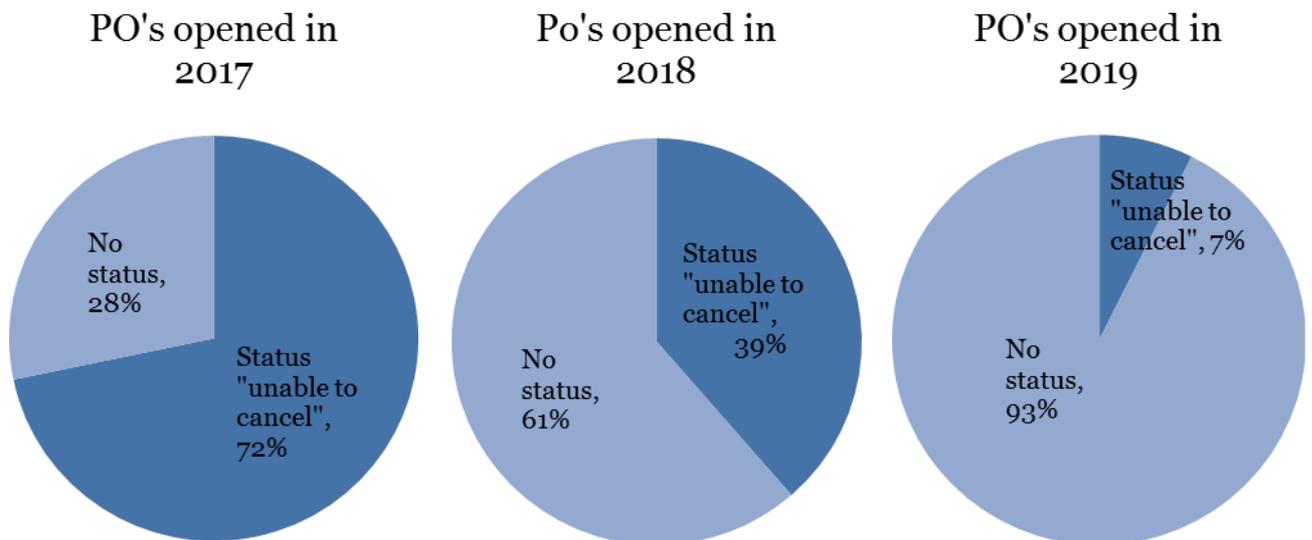


Figure 17. Ratio of POs with status “unable to cancel” for POs opened in 2017, 2018 and 2019. Data extracted on 23th of April, 2019

4.2.1. Promptness of action taken after a PO line gets marked for cancellation

Promptness of action on PO lines that are marked for cancellation is important because the chances are higher that suppliers agree with cancellation (Liaw, 2018). To measure how prompt action is being taken in Besi APac, we can look at how many of the POs are cancelled within 5 days. There is already an SGA improvement team active in Besi APac in the effort to avoid POs becoming “unable to cancel”. It has set a target for their project to achieve a 30% success rate of POs marked for cancellation that were issued within the last 5 days, which is defined by the following equation:

$$\text{cancellation success rate} = \frac{\text{PO lines successfully cancelled}}{\text{Total PO cancellation lines issued in the past 5 days}} \times 100\%$$

Cancellation rates of PO marked for cancellations within 5 days in the period of week 45 2018 until week 19, 2019 are shown in Figure 18. On average, a successful rate of cancellation of 51% has been reached in this period but it can be seen that there is considerable variation in its success which means the target set by the improvement team of 30% is not always met.

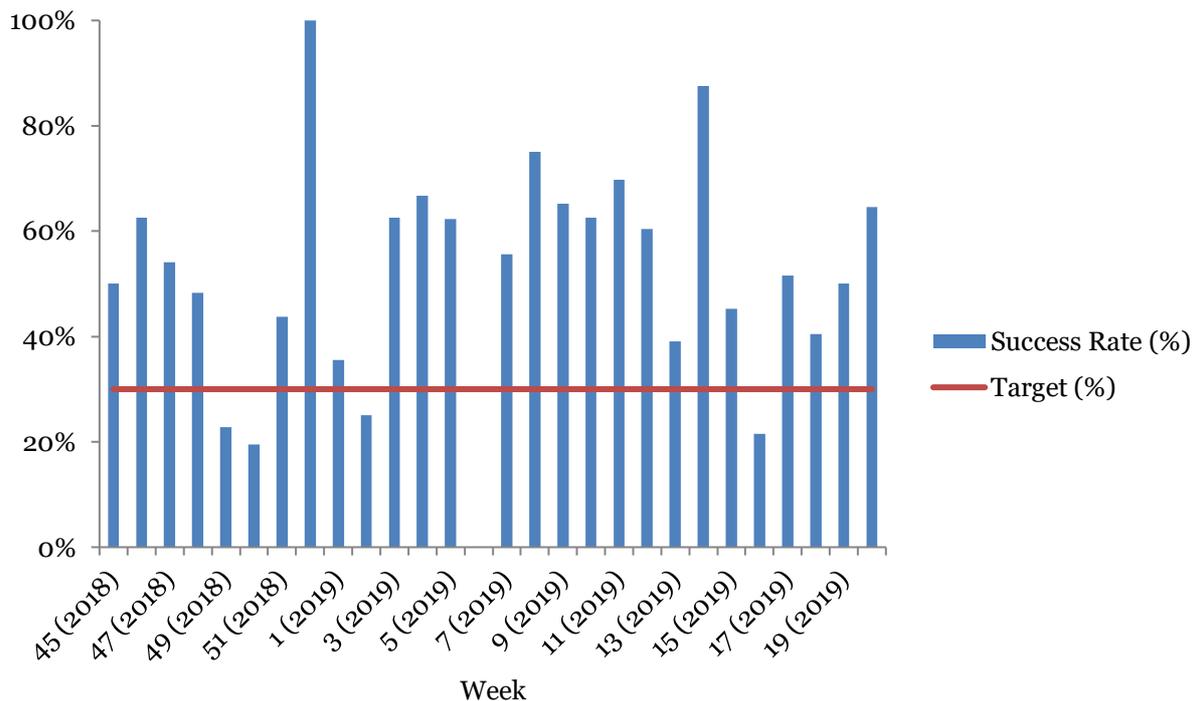


Figure 18. Success rates of cancellation week 45 2018 until week 19 2019. Data was gathered by the SGA team for improvement team of Besi APac.

4.2.2. Assignment of priority to POs marked for cancellation

In this section, sub-question 2.2 is answered. Interviews have been conducted with purchasers from VP and CMO, which can be found in Appendix 6.1.C. From the interviews it became clear that the purchasers feel a large part of their work hours every day is spent on the rescheduling and cancellation of POs. In the morning meeting they get a list from the section heads which lists the most urgent PO for cancellation. Urgency in this list is based on the scheduled delivery date of the PO: the sooner the delivery date, the more urgent it is thought to cancel it. Urgency is currently not set based on the amount of time a PO is open or the value of the PO in this list, but POs of high value might be brought to attention on an ad-hoc basis.

From the interviews it became clear that the cancellation of POs is not the highest priority for purchasers. Purchasers consistently referred to the KPIs as being the most important part they give priority to in their job, which are for defined for both purchasing sections as follows:

KPIs for VP and CMO	Target
Supplier on-time delivery	>95%
Fulfillment of wish-date for production	>80%
Obtaining order confirmation from supplier	>95%
Raw material inventory control	Inventory value <60Mil, Inventory turn rate >5
Customer on-time delivery	>95%
System complaints (QIT) and supplier incoming quality (SIQ)	QIT<0.30%, SIQ <0.70%

Purchasers viewed on-time delivery and fulfillment of wish-dates as most important of the KPIs. Note that the only KPI that can be related with PO cancellations is the KPI of inventory control. However, note that there is currently no KPI for measurement of successful cancellation rates. It can be concluded that the priority for cancellation of POs overall is thus limited because of conflicting KPIs, and focus is mainly on the list of urgent POs, which leaves action on POs that are not considered to be urgent to be postponed, leading to the high open value of PO to be cancelled.

4.2.3. Monitoring process of POs marked for cancellation

In this section, sub-question 2.3 and 2.4 are answered, which deal with how the status of negotiation of POs marked for cancellation is monitored and why they are not cancelled sooner. In the previous section it has been found that purchasers mainly assign priority to the POs that are in the urgent list. As well there is now a practice to suspend the delivery date of a PO that is “unable to cancel without obligation” to the 25th of December that year. Both are reasons for POs to sit in the system for a considerable time. This is currently also the only way Besi tracks if there is action undertaken on a PO.

To be able to remove POs which are unable to cancel without payment of obligation a decision has to be made between bringing the good in inventory or to scrap the PO and only paying the obligation. As well, a decision should be made to which place in the associated costs are charged (for example, to the right product group, to the purchasing department or to another cost center that is defined). Uncertainty about the person responsible to make these decisions can lead to these POs remaining open as well.

Current practice in Besi APac is that POs marked for cancellation but have status “unable to cancel” are reviewed after they have been open for two years. This is done because demand may come back for items. The amount of POs open in the system is thus partly due to deliberately holding them open and costs of scrapping items can even be avoided this way. It has as well been noted from the interviews that decisions on the possible actions are usually only taken after these two years. Purchasers then review together with production if there is any possibility that the goods can be used in production so that they can be brought in and don’t have to be scrapped. In this review, they consider the following possibilities in order to be able to use the materials:

- Rework: A sometimes minor change to a material is sufficient for the material still to be useful for production, so in this case it can be brought in.
- Use-up: It can be possible that a PO is out for the same material. This is often not obvious because material numbers used are not standardized for the different product sections in Besi APac. Then this PO can be cancelled, and the new PO will be brought in and used.
- Cannibalize: In case the item is a module, sometimes parts of the module can be utilized for other modules in production.

The practice to suspend the delivery date to the 25th is however not consistently done because not all causes are suspended to 25th of December. Besi has thus no clear view on the total amount of POs that are considered to be unable to cancel without obligations. As well, Besi lacks a proper tracking procedure of actions and stage of negotiations on POs that are marked for cancellation in general.

4.3. Discussion of analysis results

The high open obligation due to open POs needing to be cancelled that Besi currently is shown to be due in a large part due to external factors such as changes in the demand, customer order cancellations and forecast changes, which together represent 58% of the total value of POs and 73% in terms of the number of lines. But there is still a large room for improvement in internal process-relating factors, manual orders being the largest cause of a high value of POs being marked for cancellation. This does not mean the manual orders always really are an excess obligation; it just means that the system sees no need for them as there is no demand for the items in the system. The problem of the large excess obligation value can thus be considered to be in part a problem of perception. However, it is not clear currently which manual orders represent orders that are really needed and which one are in excess of the production demand as this demand continuously changes from time to time. In addition, it has been shown that the manual orders can have unforeseen effects on other POs open in the system leading to more POs to be cancelled. The high open value of POs marked for cancellation is also caused by a significant value of POs that cannot be cancelled without obligation that is deliberately kept open because demand may come back for the item. Costs from cancellation fees are avoided by this practice.

Besi should focus on ways to prevent POs from being opened that need cancellation by restricting manual orders first to reduce the internally causes of cancellations and have a better view of the true excess obligation. External and thus uncontrollable factors have been found to have a high impact on the number and value of POs to be cancelled as well. Although it is not possible for Besi APac to change these external factors, by focusing on improvements in the after process as well to increase successful cancellation rates and better monitoring of POs, the open obligation value can be reduced and risk for cancellation fees minimized. Future research is needed to see how forecasts can be improved at the BBP in Europe and how dampening and buffering approaches may reduce the high level of purchase order cancellations but also the frequent rescheduling of POs. As well, there is room for improvement in the monitoring of POs that need to be cancelled so that obligations are avoided.

4.4. Research validity

The following types of validity are discussed in this section:

- Conclusion validity: does a relationship between the factors and the effect exist?
- Internal validity: Is the relationship causal?
- Construct validity: do the measures (no. of PO lines and value of PO lines) measures what it claims, or purports, to be measuring (overhead costs and obligation costs).
- External validity: can the results be extended the other cases, for example to the other locations of Besi, companies within the semi-conductor industry, companies that use SAP (within or outside of semi-conductor industry), or even to companies in general.



Conclusion and internal validity

Validation of the causal factors is necessary as the causes have been registered daily by the business analyst and are not directly derived from the system. Because of time and technological restrictions (not all data can be traced backwards in the system), not all causes of orders can be validated. Therefore only the orders with highest value are validated to obtain their true causal factors. For the top 40 orders in terms of their value, the causal factors have been validated to check if the causal relationship that is made between factor and effect is correctly established. The top 40 orders by value under the manual order category for the purchasing sections VP and CMO are verified by going through history of transactions of the PO in SAP and checking if an MRP-generated purchase requisition was present.

Construct validity

The number of PO lines has been used as an indicator for the amount of time that is spent by purchasers and as a result the overhead costs of the department. Interviews have validated the claim that the time spent by purchasers is influenced highly by the number of lines that they have to process. It has however not been possible to directly link the number of lines to the exact time and associated cost. This is left to future research.

The value of PO lines that need to be cancelled is used as an indicator for the total open obligation that Besl APac has to its suppliers. The research is limited by the fact that it only looks at the open obligation, which does not mean the actual resulting costs of these POs that need cancellation for each cause. Resulting overall costs as a result of cancellations in previous three years have been shown in Section 2.1.2. However, future research will be needed to examine the exact resulting costs in terms of actual cancellation fees for each cause category and the inventory holding costs due to goods that are not cancelled.

External validity

Analysis of the frequency of causal factors is naturally only applicable to Besl APac. Future research is needed to validate if the results can be extended to Besl Leshan and to other companies. It is expected that other companies that use SAP as a tool to manage their requirements of material purchasing, or even to similar ERP systems in which demand is automatically calculated based on demand loaded into the system.

5. Design

5.1. Design goal and method

The overall design goal is to realize a reduction in the open excess obligation and to reduce the number of open PO lines marked for cancellation in Besi APac so that processing costs are reduced. Based on the results of the analysis, the goals that have been set for the design are as follows:

1. Reduce the value and number of new purchase orders being marked for cancellation which are related to manual orders
2. Reduce the open value and number of purchase orders already marked for cancellation

The design phase follows the V-model of system engineering as originally developed by (Forsberg and Mooz, 1991). In this model, the design requirements are separated into system level, sub-system level and component level requirements. The V-model highlights the need for continuous validation with the problem owners on organizational goals and the need to define verification plans during requirements development. Although the V-model traditionally focusses on the technical aspects of design, the design shall consist of both improvements in the technology used (SAP) and in the way people work with this technology. A successful implementation of the design is therefore dependent on an extensive collaboration with problem owners on the correct implementation and clear instruction of Besi APac's employees.

The detailed requirements for the design are found in Section 5.2. The design itself is separated into two parts: the design to reduce the occurrence of new purchase orders being marked for cancellation because of manual orders can be found in Section 5.3. The design to reduce the open value and number of purchase orders already marked for cancellation is found in Section 5.4. Verification and validation of the proposed design are discussed in Section 5.5 and the plan for implementation is discussed in Section 5.6.

5.2. Design requirements

The requirements for the design are separated into system level, sub-system level and component level requirements. The requirements are set based on the results of the two stages of analysis and validated in discussions with the managers of the purchasing department and planning, the finance director and the managing director of Besi APac. The requirements have been continuously updated during the design phase. Below, the final requirements that have been agreed on are shown.

5.2.1. System level requirements

The system level requirements refer to the outputs of the system as depicted in Figure 7. The requirements have been set together with the problem owners. The managing director of Besi APac has indicated that he would like the design to make sure manual orders are reduced as



much as possible, especially because it is difficult for him and finance to see which orders have been raised manually and also because they are required to reduce any manual entries in the system by their internal control standards. As has been found in Section 4.1, release of manual orders results in 24% of the excess obligation value and 6% of the number of POs marked for cancellation. Therefore, the requirements for the outputs of the system depicted in Figure 7 are set as follows:

1. The design shall reduce the excess obligation value in terms of new PO lines being marked for cancellation by 24%.
2. The design shall reduce the number of new PO lines being marked for cancellation by 6%.

Furthermore, the director of finance wishes to reduce the open value of PO lines that have been marked for cancellation because of the unnecessary risk that they pose. Managers of the purchasing department have indicated they would also like to see this number reduced especially because of the tedious negotiations with suppliers on aging POs. The third system-level requirement is therefore defined as follows:

3. The design shall reduce the open value of PO lines that have already been marked for cancellation.

The senior director of the material management department and the senior manager of procurement have defended the amount of manual orders that were released as it is often necessary because of urgent support, as has been found in the root-cause analysis of manual orders in Section 4.1.4. In a meeting with the senior director of purchasing, senior director of planning and the managing director, the fourth system-level requirement has been set:

4. The design shall maintain the flexibility of manual orders that is required in the fast-moving semi-conductor market, under the condition that manual orders are visible and are only used after their approval.

5.2.2. Sub-system level requirements

To fulfill requirements at the system level, requirements at the lower sub-system level are set. Two sub-systems are considered. In Section 4.1.4, the MRP algorithm has been found to be crucial in the occurrence of new cancellations that are a result of manual orders. Therefore, the MRP algorithm together with its direct inputs and outputs is considered to set the first two requirements at the sub-system level.

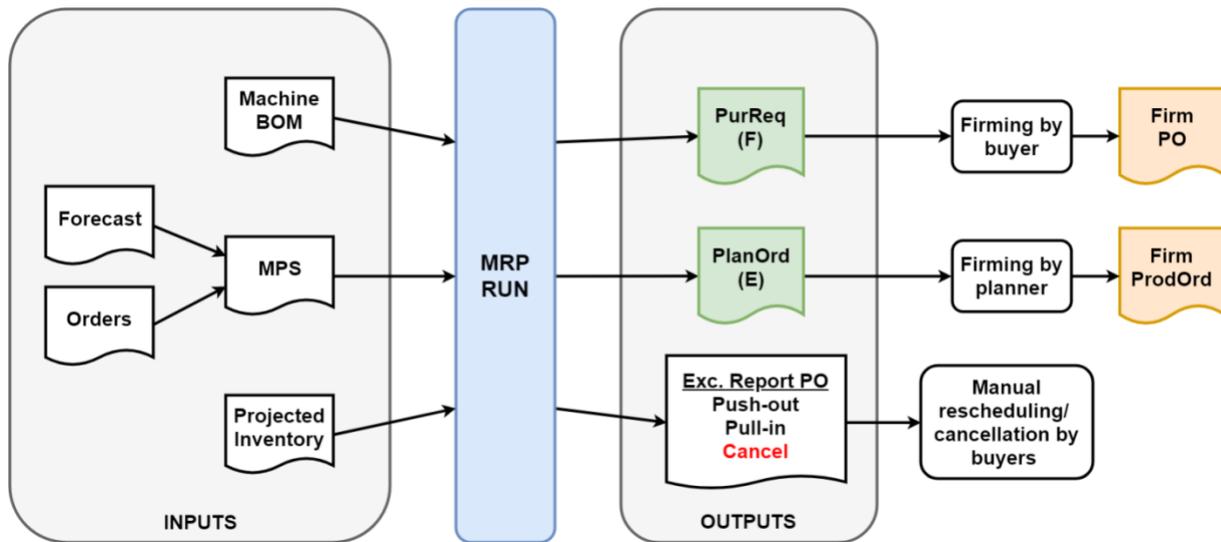


Figure 19, sub-system showing the direct inputs and outputs of the MRP algorithm, which is used to calculate required supply of materials in Besi APac.

Discussions with the problem owners have revealed conflicting motivations in setting the requirements for this subsystem. The managing director of Besi APac and the internal auditor have indicated that manual supply orders should be restricted completely following internal control goals that have been set in Besi N.V. as a whole. However, in the context of the requirements to reduce the excess obligation it has been found that the calculation of the correct supply requirements is more important, meaning that the no demand should be entered in the system for which there is no real demand. Because of the requirement to remain flexibility, orders for which there is no real demand should in strict cases be able to be filled in the system, however they should then only be issued as a supply order. This leads to the following two requirements for this subsystem:

1. Demand orders issued as inputs to the MRP system shall consist of all demand existing outside of the system, and *only* the demand existing outside the system.
2. Orders to supply material for which there is no real demand outside of the system shall only be issued as a supply order in the MRP system.

The cancellation process (displayed in Figure 4 and discussed more in detail in Section 4.2) is considered as a second subsystem, for which requirements have been defined as well. To reach the higher level requirement of reducing the open value of PO lines that have already been marked for cancellation, it has been found in Section 4.2.1 that prompt cancellation is important. Together with the purchasing SGA improvement team that has the focus on reducing POs “unable to cancel”, the following requirement has been set:

3. The design shall make sure the minimum cancellation success rate for POs marked for cancellation of 30% is met.

As ongoing improvement efforts by the SGA improvement team have already resulted in higher successful cancellation rates (as was shown in Figure 18), management of purchasing requires

the design to make sure this cancellation rate is maintained on all days as there is now considerable variety in the cancellation rates.

In Section 4.2.3, a lack of monitoring of POs that are open for a long time has been identified as the second factor causing a high open value of PO lines that have already been marked for cancellation. Discussion with problem owners focused on the duration that is acceptable for a PO with cancellation remark to be open in the system. As discussed in Section 4.2.3, keeping the PO open can be a strategy to avoid paying cancellation fees, because demand for items may come back. Any excess obligation for which it is certain demand will not come back however should be reduced as much as possible however, leading to the following requirement:

4. The design shall prevent POs with cancellation remark being open for longer than a month.

5.2.3. Component level requirements

The following requirements are related to the components within the subsystems that are considered. Following the requirement to reduce the new POs being marked for cancellation as a result of manual orders (system level requirement 1 and 2) the following requirements on the component level are defined:

1. The design shall restrict the usage of manual POs completely.
2. The design shall restrict the usage of manual Purchase Requisitions (PurReq's) to only two cases:
 - 1) There exists no real demand
 - 2) Emergency cases in times of ramp-up, to maintain flexibility

Requirement 1 is required by management because they have no visibility of manual POs and there is more visibility of manual purchase requisitions. As well management requires this as they want to satisfy their internal control goal. Requirement 2 ensures as well that subsystem requirement 1 and 2 are satisfied. An additional requirement to ensure all existing demand is created as a demand and not as a supply is the following:

3. The design shall make it possible to create manual demand in cases SAP is not able to see demand due to technological restrictions.

Management of the purchasing and planning departments have urged to maintain the flexibility of making purchases at E level in the design, as they indicate they can often reduce lead times by this practice and they have agreements with Besix partners to reduce each other's excess inventory levels.

4. Possibility to make purchases at E level shall be maintained in the design, to maintain flexibility and to reduce excess inventory of Besix partners.

However, to ensure the purchases at E level do not result in excess obligation, the following requirement is included:

5. The design shall restrict the authority to make purchases at E level and shall reduce their impact on the excess obligation.

In order to reach the requirement of maintaining the successful cancellation rate at 30% the following requirement is defined:

6. The design shall ensure proper accountability is set for cancellation of POs within 5 days of issuance

To stop the accumulation of POs with cancellation remark and open for longer than a month, the following requirement is defined:

7. POs marked for cancellation for longer than 5 days shall be monitored monthly.

5.3. Design to reduce the occurrence of new purchase orders being marked for cancellation as a result of manual orders

The focus is to restrict the usage of manual orders as a whole as much as possible. However, as in the requirements it is noted that SAP should not list items which do not have demand as such, the usage of manual orders is sometimes legitimate. This is the case for quantity contracts. Creating a demand for them in the system would reduce the visibility that they are in fact an excess obligation and thus it is strongly recommended that they are continued to be issued via manual orders. Future research should review the possibility of reducing the amount of quantity contracts in this case.

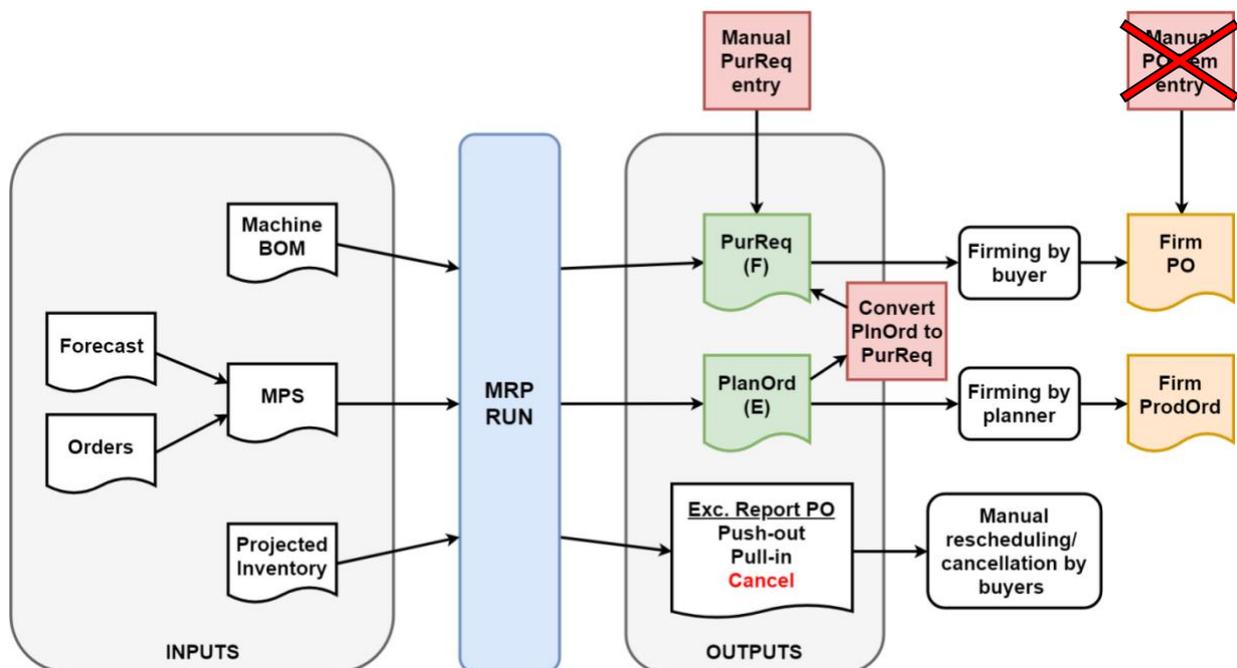


Figure 20. Manual PO entry should be restricted under the first recommendation.

The second recommendation that is made is to restrict the usage of manual PO completely. Manual POs are not visible to management and only go for approval if they have a large

enough value. To improve control of the manual orders being made, they should only release a PO when there is a purchase requisition generated by SAP. It is not possible to remove the authority of buyers to create manual POs as the transaction code used in the SAP is the same for the creation of a manual PO as it is for a PO based on a purchase requisition. Therefore, it should be made visible in the MM daily report which POs have been raised without a Purchase requisition. This is a task for internal control to continuously monitor and question POs that are being raised without a purchase requisition by the system.

Furthermore, the possibility to raise a manual purchase requisition is then restricted to only the case where there exists no real demand, for example as is the case under the call-off of expired quantity contracts. As there is approval needed for manual purchase requisitions, finance and the managing director are in this case able to ensure that manual purchase requisitions are also only used in these particular situations.

In the case of demand really existing, such as the case of “Pre-order request”, where planning knows an order is coming but it is not visible in SAP yet, a sales order request form can be used to create manual demand. The sales order request form will be a formal document requesting entry of a sales order into SAP which should be approved by the manager of the planning department. This sales order request form can then be processed by the product data controller in Besl APac who is able to enter a demand manually into the system. Figure 21 shows where a sales order request form is used to enter demand in the system.

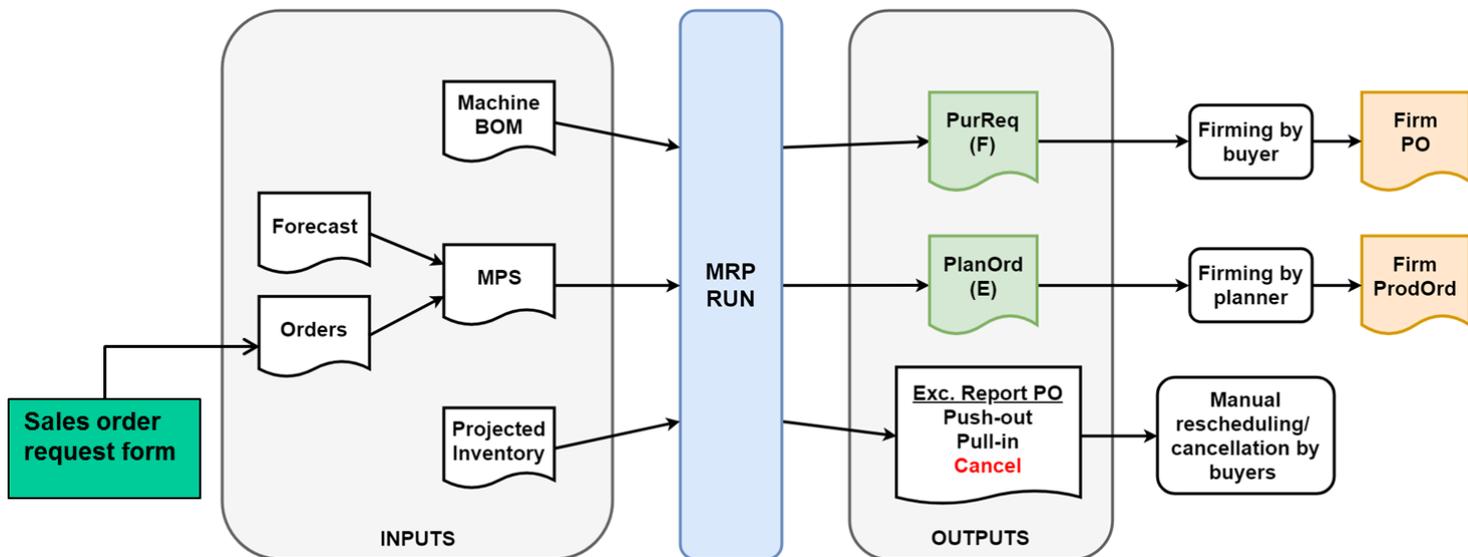


Figure 21. The sales order request form can be used to enter a manual demand in the system.

In the workflow of the managing director and of finance, it can be made visible which purchase requisitions have been created manually using a creation indicator in SAP. Therefore, if a manual order is really needed because of urgency and the wish of the problem owner to maintain flexibility, it should only be issued via a manual purchase requisition or planned



order. In this way, manual orders are more visible and require approval from finance, reducing the risk for excess obligation. As well, they will be deleted after a MRP run so that any excess POs that have not been approved will be deleted automatically from the system.

Considering the requirement to maintain flexibility, the possibility to make purchases at E level should be maintained. There are two possibilities to reduce the resulting risk for cancellation fees:

1. A change in the system so that there is more flexibility in the system. Right now, Besi uses two procurement types, one being F for purchase items, and one being E for make items. SAP has the possibility for a third procurement type X, which allows more flexibility to make a machine in-house one time and the next time outsource it. It can also be set as partly made in-house and partly out-sourced with different ratios of outsourcing being possible.
2. Maintaining current way of purchasing at E level but implement proper controls to restrict the usage of purchases at E level and holding the person requesting a change in procurement type accountable for its impacts.

It is recommended in this case to not make the system-wise change but focus on the second option, as the system wise changes can have unintended consequences which should be properly considered and also people have to be instructed how to work with the new procurement type. As well it still results in excess obligation in the scenario that the procurement insourcing/outourcing ratio is changed when purchase orders are already launched. The proper workflow to ensure proper control of purchases at E level and increasing accountability of the requestor is as follows:

1. Put all open purchase requisitions and purchase orders on hold for the dependent requirements (dependent requirements are the material requirements for in-house production of a planned order).
2. Formal request form for purchase at E which needs approval from finance. Attached to this form shall be a list with all dependent requirements and their value.
3. Following approval, the requestor is responsible to make sure dependent F items are cancelled promptly.

5.4. Design to reduce the open value and number of purchase orders already marked for cancellation

The design for the process of cancelling POs after they are marked for cancellation will consist on increasing prompt cancellation of POs after they get a cancellation message and a way to periodically monitor open PO marked for cancellation, as per requirements.

To increase the prompt cancellation, the efforts of the existing SGA improvement team in Besi APac should be continued. Management should properly consider how the current KPIs lead to a neglect of purchasers to take action on cancellation of POs as they are only held

accountable on these KPIs and this will be their primary incentive. Management can consider implementing an extra KPI to ensure the efforts of purchasers to meet the target level of 30% success rate of POs cancellation within 5 days after it is issued to the supplier. However the current focus on fulfilling wish dates of suppliers to fulfill is defensible because of the importance of short lead-times in the market. Reducing cancellations can however also ensure more goodwill from suppliers, improving their service levels (Terwiesch *et al.*, 2005) and in this way increase performance on the other KPIs such as supplier on-time delivery and supplier incoming quality. More research is needed to assess the possible positive but also the negative effects of introducing an extra KPI.

However, it is recommended that not only purchasers are held accountable for prompt cancellation. Instead, responsibility should arguably be at the origin of the cause of the cancellation to urge prompt cancellation by the purchasers on these POs. The person causing POs that require cancellation should become responsible to urge prompt cancellation as soon as they are aware of higher level changes, for example in the following cases (from the cause categories, see appendix B.)

- Planner for changes in planned orders or production orders that could affect dependent child items
- Requestor of E→F change as noted before.
- Material planner for changes in the BOM
- Production planner for returns or removal from production orders

Shifting this responsibility is however a change in mindset that requires time, and ultimately, the purchaser is still responsible to cancel the PO. However, it should be a team effort to make sure any costs of excess obligation are reduced by setting the right priority. As well increased visibility of the cause of the cancellation is needed to hold the appropriate persons accountable. To make cancellation of POs a team effort and also to increase the visibility of causal factors so that the right persons can be held accountable, the next improvement that is suggested is useful.

The next improvement that is recommended is to implement a monthly review of the status all open PO marked for cancellation. In this meeting, the responsible purchaser that issued a PO should brief the management and the product groups on the status of negotiation with the supplier. As well, the business analyst should present his results on the cause origin of the cancellation so that the appropriate persons can be held accountable and costs can be allocated to the right place. In the meeting, a decision should be made based to scrap the PO (paying the obligation but not taking it in as inventory), bringing the PO in, or pushing out the delivery date. To make these decisions, the following questions should be asked:

1. Is it possible that demand for the item comes back or is it already a phased-out item?
2. Is there a possibility to rework, use-up or cannibalize any materials?
3. At which stage is the supplier in production and is he willing to hold production?



These questions are being asked now already, but Besl now only considers this after two years of holding the PO open. By introducing a monthly review instead of only after two years, the amount of POs with status “unable to cancel” can be avoided and as well POs for which it is already clear that there is no possible use can be scrapped. An added benefit of a more routine review is that the cancellation fees can be charged to the right place in time, possibly the customer if the cancellation was a result of an order cancellation.

5.5. Verification and validation of the design

In this section the verification and validation steps that are taken during the analysis are outlined. The definition used for verification and validation of the design are adopted from the IEEE standards for system and software verification and validation (IEEE, 2016):

- *Verification*: “The evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition. It is often an internal process. Contrast with validation.”
- *Validation*: “The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders. It often involves acceptance and suitability with external customers. Contrast with verification.”

Verification of the design to the design requirements

To evaluate the compliance of the design with the component level, sub-system level and system level requirements, verification steps have been performed during the design phase. The requirements are set in such a way that they are testable. Because the analysis has shown manual orders represent 24% of the value of POs and 6% of PO lines, it is expected that the designs to restrict usage of the manual orders will result in this amount (for validation of the analysis, refer to Section 4.4). Because of the variety in orders that Besl receives however and because the analysis is based on historical data, the exact reduction in excess POs can only become clear during evaluation after the design has been implemented.

The recommendations made to make to increase accountability for PO cancellations and to reconsider KPIs have not been fully developed into a design yet. Therefore it cannot yet be verified if these recommendations will result in a minimum cancellation success rate of POs marked for cancellation of 30%. Based on the analysis in Section 4.2, it has become clear however how the focus on KPIs in particular leads to a prioritization of these KPIs, and neglect in the prompt handling of cancellations. It is expected that improved prioritization and accountability of cancellations will improve the cancellation success rate based on this analysis but the outcome will depend heavily on the exact design that is developed based on these recommendations made.

The monthly monitoring process that is recommended for POs marked for cancellation for longer than 5 days is expected to result in fulfillment of the requirement to reduce the open value of PO lines that have been marked for cancellation and open for longer than one month. The process that is in use now in Besl APac to review cancellation after two years has been shown to result in the fact that no more POs are aging more than two years (See Section 2.1.3



PO lines opened in 2016, 2017 and 2018 which still require cancellation). Because often Pos should be kept open when demand is expected to come back, monthly reviewing will not delete the entire list of POs marked for cancellation every month. However, a reduction and certainly the accumulation of POs marked for cancellation is reduced by the monthly monitoring process.

Validation of the design to the organizational goals and user requirements

Validation of the design's requirements and the design itself to the organizational goals and user requirements has been a constant process during the design phase. Requirements have been updated after each meeting with problem owners and other stakeholders. The organizational goal of obtaining a reduction in excess obligation is directly linked to the top system level requirement to reduce the value of new POs marked for cancellation by 24%. The definition of excess obligation is the open PO value that is in excess of internal production. The PO value that has a cancellation message in the system may however not represent true excess obligation, but this is not possible to see from the system currently. As a result of this technical limitation, the PO value with cancellation message is regarded as excess obligation. Manual orders in the system for materials that actually do have a demand (such as the pre-order request) should arguably be removed from the excess obligation value. However, it is from the dataset not visible to see which part of pre-order requests actually did end up having demand and which part resulted in a truly excess obligation. Only after implementation of the design it will be possible to evaluate the true impact on reduction of the excess obligation.

The other organizational goal of reducing the processing costs is directly linked to the reduction of new PO lines marked for cancellation that the design has been verified to reduce. The amount of new PO lines marked for cancellation is shown to be reduced by 6% as a result of the restriction of manual orders. However, the number of lines is only indirectly linked to the processing costs. The existing overhead costs have been estimated in Section 2.1.2 by the following equation:

$$\text{Estimation purchasing overhead cost due to cancellation process} = \text{Payroll expenses purchasing} \times \frac{\text{no.of cancellation POs}}{\text{total POs released}} \times 2.$$

In previous years, this estimation based on the number of PO lines was 645,498.46 MYR on average. Assuming the number of released PO's and the salaries and headcount of the purchasing department stay the same, a reduction of 6% in the number of POs marked for cancellation will result in an estimated reduction of overhead costs of 38,729.85 MYR on a yearly basis. The designs proposed for reducing the amount and value of POs currently open in the system waiting to be cancelled are expected in a further reduction of the total value and number of PO lines that are already open, so a further reduction can be expected in this regard, however the exact value should be evaluated after implementation.

5.6. Implementation and evaluation of the design

Parts of the proposed design have already been implemented in Besi APac, such as the restriction of manual PO entry and only allowing manual Purchase Requisitions and the



creation indicator that shows which manual purchase requisition in the workflow of finance and the managing director. It is suggested that after a month time it is evaluated how many of the POs are still ordered manually and verified if results in a reduction in the overall excess obligation value and number of open POs to be cancelled.

Other parts of the design still require implementation. This section provides guidelines for a successful implementation and evaluation of these elements. Recommendations are made in Section 5.3 and 5.4 are not developed to extend so that they can readily be implemented. The exact layout of the sales order request form that is proposed as well as the form that should be used for purchases at E level is left to Besi. Requirements have been set for these designs which that have been shared with the planning director, which he can use to implement this form. To ensure successful implementation of the restriction on manual POs being launched by purchasers, in the first month a weekly review by the internal controller is recommended. If successful this can be replaced by a monthly review. The internal controller has been instructed that he should download the list of all issued POs from SAP over either time-period for this purpose, and find all POs that have been issued without a purchase requisition number. This way he can evaluate the number of POs raised manually, and he is able to see who has raised the PO. The other measures that are proposed should be verified and validated in a similar manner to see if the set targets in the requirements are met. If they are not able to meet the set requirements or if there may be other unintended consequences, the problem-solving cycle should be started again to analyze why the recommendations do not meet requirements and which changes in the design may be needed.

5.7. Discussion of design phase

Some parts of the design have been worked out in full and some need further work before they can be implemented. Therefore some design steps are still required before implementation can take place as has been discussed in the previous section. Verification and validation that the design meets both the system requirements as the organizational goals has been performed where possible. The design is in this way expected to reduce in particular the internal causes of the excess obligation and processing costs associated with purchase orders marked for cancellation. Research supports the statement that this focus on internal causes should result in less purchase orders that get marked for cancellation (Mather, 1975). Future design proposals should target the external factors as well but only after internal causes have been shown to no longer have a significant impact on these cancellations. As well, management would like to extend the results to the Besi plant located in Besi Leshan. As Besi Leshan shares the same system (SAP) which uses the MRP algorithm to calculate required supply, the proposed design is expected to be able to readily be applied here, especially concerning the recommendations on restricting manual orders. Procedures of handling POs that already are marked for cancellation by purchasers could be different in Besi Leshan, however. On this part of the design, further research is needed to evaluate the possibility of extension to Besi Leshan.



6. Conclusion

The goal of this design project has been to reduce the excess obligation and processing costs associated with purchase orders that are marked for cancellation at Besi APac. It has been shown that the high open value and number of PO lines which are marked for cancellation is influenced both by daily new POs which are marked for cancellation, but also is in large part due to POs remaining open in the system while they are marked for cancellation. Therefore the analysis has addressed these two sides of the problem.

It has been shown that new cancellations are largely caused by external factors such as changes in the demand, customer order cancellations and forecast changes. However, room for improvement in internal process-relating factors has been found which should be addressed before applying any dampening or buffering methods to external causes. Of the internal process related causes, manual orders have been found to have the most impact on both value of excess obligation and lines. Five root-causes have been identified for these manual orders on which three different design recommendations are made: (1) Restriction of manual PO entry and only allowing manual purchase requisitions in necessary cases such as call-off of expired Quantity Contracts; (2) Use of a sales order request form to enter manual demand in the system in cases of consigning material from one supplier to another and for pre-order requests; (3) proper control measures for purchases at E level. These recommendations are expected to reduce the value of new PO cancellations by 24% and the number of new PO lines by 6%.

In the second stage of analysis it was found that improvements were possible in the prompt cancellation of POs and that better monitoring of POs open for longer than 5 days was required. It was found that for prompt cancellation, current efforts to improve the successful cancellation rate within 5 days have already been quite successful but proper accountability of cancellation POs is lacking and now primarily lays on the purchasing department. It has been recommended therefore to management to consider measures in the future to shift this responsibility to persons causing the PO to need cancellation. Management should also consider how the focus on the current KPIs causes a possible neglect of cancellations. How the priority can be shifted to PO cancellation and if an extra KPI is of benefit in this case however needs future research. As well it has been proposed to implement a monthly review of cancellations to better monitor the status of negotiation and make decisions to charge out and cancel obligation sooner

The suggested improvements should lead in to a reduction in the open value of and number of lines of PO lines that are required to cancel at any time, and in effect to reduce the excess obligation that Besi currently is exposed to and the processing costs associated with negotiating and cancelling of the PO lines. The exact reduction in excess obligation and processing costs will however only become clear after implementation, so continuous monitoring is required to verify and validate the implemented solutions to the organizational goals.



6.1. Future research

Beside the reduction of the open obligation of cancellation and the internal process related causes, future research may take a broader view to also consider the external causes and possible dampening methods to external variability. As well a broader view may be applied by considering the problem of frequent shifting between pull-in, push-out and cancellation as a whole. Literature indicates that improvements in data integrity are crucial to reduce the effect of frequently shifting recommendations by the system known as “MRP nervousness” . Possible improvements in the internal processes still exist however: future research may look into an increase in how material numbers across product groups may be standardized and bar-code scanning can be used to improve MRP’s knowledge of the inventory levels. Existing research suggests that these internal causes should be considered before considering the dampening methods that can be applied, such as safety stock adjustments, lot sizing decisions and reconsidering of the rescheduling frequency and planning horizons. All these dampening methods are already in place in Besi APac but there may be room for improvement in these aspects.



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Appendix

A. Cause categorization of PO cancellations used for reporting in Besi APac

- a. Forecast changes
- b. Customer order cancellation
- c. Manual purchase order to supplier (project stock)
- d. Engineering change notice
- e. Customer order return or remove from machine or customer order or production order or order cancellation
- f. Incorrect Order Confirmation quantity
- g. PO quantity higher than the amount suggested by SAP
- h. Quality issues with previous orders
- i. Changes in the safety stock
- j. Stock adjustment by the warehouse
- k. Decision to make part in-house instead of buying by material planning

B. Own cause categories

No.	Category	No.	Category
1	BOM change	22	Old PO cancelled and replaced with new
2	Change in PO quantity	23	Order cancellation
3	Combine Purchase Requisition for PO issuance	24	Other
4	Delivery completed indicator removed	25	Parent change from E to F
5	Delivery too late	26	Parent change from F30 to F
6	Demand change	27	Partial delivery for PO line
7	Engineering Change Notice	28	PO quantity higher than in Purchase Requisition quantity
8	Forecast change	29	PO quantity split into PO line
9	Forecast consume	30	PO rescheduling
10	Hit-rate remove	31	Project stock purchase
11	Incorrect Order Confirmation (OC) update by supplier	32	Quantity moved from block stock
12	Item change from F to E50	33	Reject
13	Long lead item	34	Remove from Production Order
14	Manual order to supplier	35	Return from Customer Order
15	Manual production order conversion	36	Return from Machine Order
16	MOQ purchase rescheduling	37	Return from parent level
17	MOQ purchase, New PO with earlier date than old PO	38	Return from Production Order
18	MOQ purchase, Partial delivery for PO line	39	Return from vendor
19	MOQ purchase, PO quantity split into PO line	40	Safety stock reduce



20	New PO with earlier date than old PO	41	Stock adjustment by warehouse
21	Newer PO received earlier than old PO	42	Unable to remove during MRP run

C. Interviews purchasers

Interview with [REDACTED], purchaser for Vendor Parts (VP)

1. What does a typical working week look like for you?

The weekly routine is that on Monday all the POs to be rescheduled are shared in an excel file. These consist of pull-ins, push-outs and cancellations. Purchasers use their workbench in SAP to send out the rescheduling notifications to the suppliers. Every day we have a morning meeting in which a list of material shortages is shared. These are the urgent POs that need immediate action. The POs in this list are often past the required for production start date that is suggested by SAP.

Aside from these routines, there are always issues coming in the mail, by phone or in person. These might come from planning, procurement or the supplier. For example, planning needs certain parts sooner or they require cancellation of something. A supplier might contact us because a part cannot be delivered.

1.1. Are you aware of the ISO standardized procedures?

Yes, but I only looked at them when I joined the purchasing team. Afterwards I haven't looked at them, only when they make changes in the procedures we will be notified.

1.2. Do you generally follow these procedures or is it sometimes more convenient to do things differently?

No, the procedures have to be followed. Sometimes it is also not possible to do it differently. For example, for an order to be issued you have to first open the PO in SAP and ask for approval, only then you get the PO number which you use to send the PO. You cannot do it another way. There are however things which we do daily for which there are no official procedures. These are often the issues that come in on the mail or from management.

1.3. How much freedom do you have in the handling of POs?

As buyer we have to follow the purchase requisitions that are given by SAP. In SAP the price of the PO, the required supplier and the quantity is set. We have freedom in how and when we



handle the orders, and which we give priority. Normally we give priority based on the need date suggested by SAP, or if planning requires us to prioritize differently we follow that. If we want to issue a PO, it first has to go for approval to either the section head (Pun), material management (Ming-Chee) or the managing director (Henk-Jan), depending on the value of the PO. Only then it can be sent out (issued) to the supplier.

One thing we have freedom in is that we can change quantity of an order to make use of stacked prices. For example when there is no delivery fee if you take one item more. But always we need approval before it is sent out.

1.4. What is more important for you, decrease costs by using stacked prices or speed of delivery?

Depends on the case. If an item is really urgent we will not look at costs so much. Otherwise we might wait with an order until demand is high enough to have a quantity for which we can take advantage of the stacked prices.

2. What do you give highest priority to in your job? (i.e. OTD/costs/ preventing obsolete items/ preventing shortages, cost saving etc.)

There is not really one thing I would say I give the highest priority to. Things are usually in parallel and it is in general case by case. But if for example there is a shortage of material and is needed urgently to be able to meet a machines shipment date, delivery time will become most important. In other cases it might be the costs has more focus.

2.1. What do you give priority to when you get the morning list of urgent POs (they are many)?

From the morning list, every buyer gets his own part of it. Each buyer has their own suppliers they sent POs to, so based on this the urgent POs are divided between the buyers. Then we prioritize the urgent POs based on the shipment date of the machine. The urgent POs are generally past the production's need-by-date so they are all past-due for delivery.

2.1. What about the list with POs to be cancelled?

This is the same list, however these are ordered by the scheduled delivery date for the PO. The sooner the delivery date, the higher the urgency to cancel them. This is because the chance is higher that the supplier has finished its production when the delivery date is sooner.

1. What are you held accountable for? (targets)

These would be the KPIs. Every month during MM meeting there is an assessment of the performance on the KPIs. How you perform on these will affect your bonus. In addition, there is an appraisal if you have done extraordinary things.



2. *What is the biggest challenge in your job?*

Definitely the PO forecasts not being accurate. It causes us a lot of trouble because we have to reschedule and cancel POs all the time. The forecasts are really unstable due to the nature of the semiconductor market. The list of urgent PO cancellations becomes so large mainly because of frequent changes in the forecast.

The long production lead times are also a problem. Often a shipment date is agreed with a customer for whom a shorter lead time is required. Then items that are needed have to be brought in sooner, often when it is not known what the need for materials will be. So, an excess of material is ordered of which a large part has to be cancelled later. As well POs have to be pulled in which brings expedite costs with it.

3. *Do you think purchase cancellations are a problem?*

Yes, definitely.

4. *Why do you think they are a problem?*

If you are late (generally more than 3 days) with the cancellation of a PO, there generally exists an obligation to the supplier. Often a supplier has to buy parts as well for his own production and he has put working hours into it, so he has already made costs. When it is unable to cancel you have to buy the item and there are higher inventory costs.

5. *What do you think are the major causes for purchase cancellations being needed?*

There are a lot that I could think of. They are for example:

- Customer order cancellation.
- Double demand: not sure why, I think some kind of system error.
- Human error: for example instead of 2 pieces they buy 5.
- Original supplier may not be able to support on time, so new PO is sent out. Old one gets cancelled. This is especially common with CSR items.
- Wrong parts are sometimes purchased, for example due to an error in the machine BOM.

6. *What do you think would be the most important thing that would make your work easier and reduce the need for purchase cancellations?*

Improved forecasting and less customer order cancellations, however they are not under our control. I don't know how the other causes could be solved, perhaps better training.



1. *What does a typical working week look like for you?*

Similarly to VP, we have the weekly rescheduling meeting for POs to be rescheduled and the daily meeting for urgent POs because of material shortages. Aside from that we are constantly monitoring the PO to be launched in SAP and we are in close contact with suppliers to set delivery dates and other terms.

On Mondays, the forecasts are shared from the BBP. Changes in the forecast are however also sent during the week, for instance if there is an important or urgent change. Often, the supplier shares the forecast already on Friday, but because of the time difference we will only see it on Monday. We are very flexible so sometimes they also call us after working hours.

2. *Are you aware of the ISO standardized procedures?*

Yes every buyer is thought these procedures during the training and we have to adhere to them.

3. *How much freedom do you have in the handling of POs?*

We are very flexible. We check the need-by-date in SAP but don't follow directly what it says. We work closely together with the product groups (Die attach and Packaging and Plating) to establish the needed delivery date we sent to the supplier.

4. *What do you give highest priority to in your job? (i.e. OTD/costs/ preventing obsolete items/ preventing shortages, cost saving etc.)*

Definitely the on-time delivery is most important. The target is that it should be higher than 90% at least and preferably higher than 95%. It is important especially for CMO as a lot of items are needed start the production. Customer specific requirements are often only coming in later while short lead-times are demanded. Therefore we need to have short delivery lead-times from suppliers. We actually work together with the supplier so that they can speed up their assembly processes, by doing the purchasing for them. Sometimes we or another Besix location has the parts in-house that are needed for the modules that are assembled at the supplier. By working together this way the lead-time can often be shortened.

5. *What are you held accountable for? (targets)*

We have the same KPIs as the other purchasing sections.

6. *What is the biggest challenge in your job?*

I like my job very much so I don't really see challenges. But the most challenging would be that we always have to be flexible and work very closely with Planning, the product groups and the supplier to establish the optimal delivery date (not too soon, not too late), to meet the OTD target and to continuously shorten the delivery lead times.

During ramp-ups we are the busiest because a lot of items are requested. We often exceed the amounts agreed on in the quantity contracts, which means supplier cannot always meet the lead times anymore. We are then continuously calling and visiting suppliers to make sure parts are on time.



7. *Do you think purchase cancellations are a problem?*

Yes, definitely

8. *Why do you think they are a problem?*

They are a daily thing we have to deal with and spend a lot of time on. As well suppliers get annoyed because we have so many.

9. *What do you think are the major causes for purchase cancellations being needed?*

Largest cause would be the forecasts that are inaccurate. We get a long list with hitrates for CSR items, but we only really need a few of them. As a result a large part gets cancelled. As well because short lead times are required but delivery lead time is long especially for CMO, we have to order weeks in front when demand is not sure.

10. *What do you think would be the most important thing that would make your work easier and reduce the need for purchase cancellations?*

Incoming forecasts should be improved, but as this is not under our control it might be good to change the way we deal with this forecasts. Now we just have to buy everything that is in the forecast. If we get more flexibility in what we buy that would probably be an improvement.

D. Payroll expenses purchasing department

Payroll expenses Purchasing

2016	2,022,860.63 MYR
2017	2,496,764.74 MYR
2018	2,401,092.45 MYR



E. 5-why analysis

Problem	1 st why	2 nd why	3 rd why	4 th why	5 th why
Manual orders to supplier which result in POs being marked for cancellation	Manual POs are being issued without a Purchase Requisition	Urgent support is needed	Supplier A to unable to meet requirements, new PO placed to different supplier	Supplier is unable to meet the wish date	
				Item does not meet quality standards	
		Pre-order Request by planning	Planning knows sales order is coming	The demand is not yet reflected in SAP yet	
		Technical restriction to create demand in system	Case in which Besi needs to Consign material from supplier A to supplier B	Supplier does not want to buy from competitor	
	Manual Purchase Requisitions are being entered in the system	Call-off of expired quantity contracts (QC's)	There is no demand in the system for the remaining items in the QC	Deal made with supplier to purchase a quantity in the future based on forecasts	Forecasted demand not accurate
	Planned Orders are being converted into a purchase requisition	Planning decides to buy a module or machine instead of making it in-house (Purchase at E level)	Urgent support is needed	Customer demands short lead times	Insufficient capacity to meet demanded lead times