Development of a Buffer Monitoring Dashboard

by

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Submitted in partial fulfilment of the requirements for the degree of

BACHELORS OF INDUSTRIAL ENGINEERING

in the

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY

UNIVERSITY OF PRETORIA

October 2012
Executive Summary

Theory of Constraints is a powerful philosophy and could improve productivity as well as inventory control if implemented successfully. However, to date the implementation of Theory of Constraints principles as embedded in resource planning systems has been less successful. One possible reason for this lack of success is the challenge to match TOC with MRP-based Enterprise Resource Planning (ERP) system.

Since most industries are converging to ERP for improvement of management, competitiveness, communication and productivity, it would be of great value to be able to embed resource planning principles of TOC into an existing Enterprise Resource Planning system.

The purpose of this project is to define and develop a functional model in an Excel spreadsheet using data from a MRP based ERP system that will monitor buffers for effective management. Data from Syspro will be exported into an Excel spreadsheet. Two buffer monitoring models were developed using Excel and pivot charts. One model was developed where the buffer penetration was calculated for a current buffer monitoring dashboard and summarised in a graphical dashboard with colour zones. The other was developed incorporating Time Phase Planning which is an MRP principle as well as using the concept of Dynamic Buffer Management which is in essence a TOC principle, also with colour zones.

Analysing the buffer monitoring dashboards can be used to assistance in establishing whether the current buffer level is sufficient or not. If a product’s buffer penetration has four consecutive Green Zone Periods, the buffer level is too high. Three consecutive Red Zone Periods means the buffer level is too low. In either scenarios the buffer would be increased or decreased by 20%.

Factors that contribute to choosing a specific buffer monitoring system were discussed and the conclusion was made that buffer management can be achieved by evaluating past buffer penetrations as well as with projected buffer penetrations which will assist in allocating the correct buffer level for the planned future demand and supply.
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1. Introduction

1.1. Background

iPlan is an industrial engineering consultancy firm that design, manage, implement and support business processes that carefully balances best practices to suite their clients’ needs.

Part of iPlan’s business objective is to implement Enterprise Resource Planning (ERP) systems to support and automate business processes. These systems integrate all departments in a business, from manufacturing through to finance. ERP according to Umble, Haft and Umble (2002) provides two major benefits that do not exist in non-integrated departmental systems: (1) a unified enterprise view of the business that encompasses all functions and departments; and (2) an enterprise database where all business transactions are entered, recorded, processed, monitored, and reported.

Taking a closer look at an ERP system, one of the sections in the system is Operations and Logistics, which consist of many functions including inventory management, materials management, plant maintenance, production planning, project management, purchasing, quality management, routing management, shipping and vendor evaluation according to Umble, Haft and Umble (2002).

ERP systems have many operations and logistics advantages according to Umble, Haft and Umble (2002) such as reduction in inventory, better forecasting of demand and improved cash management.

ERP implementations have traditionally acquired a poor history in delivering on these benefits. iPlan has developed a methodology highlighting the specific objective of an implementation, with the accompanying benefits:
iPlan have completed many successful MRP-orientated ERP system implementations in the industry and have often enhanced planning with TOC principles. The TOC enhancements, however, remain largely project and customer based, without standardisation and formalisation as part of a standard ERP solution offering.

Goldratt’s Theory of Constraints is a philosophy that identifies the constrained resources and sets the system’s capacity according to that resource.

In contrast, ERP systems deploy a Manufacturing Resource Planning (MRPII) model, using time phased planning as well as bills of materials to identify materials needed for production, MRP provides forward visibility of material requirements, but is complex and requires a lot of data with high levels of accuracy.
1.2. Problem Statement

TOC principles such as constraint management, synchronised processes and buffer management have been well accepted in industry, but no ERP solution have included these philosophies in their solution. iPlan have successfully developed customer specific solutions as part of implementation projects, but these have never been properly defined or researched.

There is therefore a need to define a buffer monitoring system with TOC principles (Buffer Management) as well as MRP principles (Time Phased Planning).

1.3. Project Aim and Scope

The aim of this project is to develop an add-on module to an existing ERP system, SYSPRO, which will use MRP based data, but will deploy Buffer Management Principles while using buffer penetration to identify the need to change the level of buffer for a product to create a practical and simple planning environment.

The MRP principle of Time Phased planning is integrated within the Buffer Management Principle. Thereafter an examination will be done as to when and where these types of models can be used in a manufacturing environment.

The following aspects will be addressed in the project:

- Research is done to deliver a detailed literature review of TOC and MRP resource planning principles. This review will be presented in the form of a user requirement specification for the proposed module.
- A process and system blueprint is defined, which includes:
  - Environmental pre-conditions;
  - Data inputs and integration;
  - Buffer Penetration Logic;
  - System outputs and integration; and
  - Reports
A technical specification must be compiled. This must include:
- Screen layouts;
- Data interface points;
- Output calculations; and
- Report layouts

An Excel spread sheet solution will be developed in Excel. With the help of iPlan this solution can be used by Syspro. It will be used for final sign off by the various role players.

The Excel spread sheet will be handed to the iPlan development team and will be developed accordingly.

1.4. Project Approach and Deliverables

Phase 1: Literature study, system analysis and requirement specification
A literature study will be done to ensure that the solution is based on best practices within the environment. This must be combined with a thorough understanding of the SYSPRO environment.

The deliverable of this phase is a user requirement specification, outlining the basic functionality requirements and the desired outcomes.

Phase 2: Process blueprint
A blueprint will be defined for the solution. The blueprint will describe the sequence of events within the solution, highlighting:

- Required pre-conditions
- Data and user inputs
- Calculation logic
- Data and graphical outputs

The deliverable of this phase is a blueprint document, signed off by the project sponsor.
**Phase 3: Technical specification**

The technical specification transforms the blueprint into a systems or technical document. It includes:

- Entity relationship diagram
- Data structures
- Screen layouts and keyboard logic
- Technical interfacing

The deliverable of this phase is a technical specification signed off by the iPlan development manager and project sponsor.

**Phase 4: Prototyping**

Prototyping will be done in Excel, building a working solution based on the previous phases. The prototype will be presented to the various role players within iPlan for sign off.

The deliverable of this phase is a presentation workshop and sign off by the iPlan development manager and project sponsor.

Upon completion of the prototype, the solution and supporting documents will be handed over to the iPlan development team for inclusion in their suite of products.
2. Key concepts of TOC and MRP

2.1. Theory of Constraints

Goldratts Theory of Constraints is a philosophy that identifies the constrained resources and sets the system’s capacity according to that resource.

Theory of Constraints uses a planning and control system called Drum-Buffer-Rope, the drum represents the master schedule for the constrained resource, and this could be seen as the beat of the system as the system cannot run any faster than the constrained resource. The buffer represents a time period that the bottleneck will receive material earlier, this makes inventory accumulate by the bottleneck to assure the bottleneck never waits for material unnecessarily. The Rope is a sort of communication within the production which will specify if the buffer is in need of material or not.

Goldratts Theory of Constraints has “Five Focusing Steps of TOC” listed below:

1. Identify the system constraints
2. Decide how to exploit the system constraints
3. Subordinate everything else to that decision
4. Elevate the system constraints
5. If, in the previous steps, the constraints have been broken, go back to step 1, but do not let inertia become the system constraint.

(Jacobs, Chase, and Aquilano. 2009)

Theory of Constraints recognises resources as bottlenecks and non-bottlenecks or a critically constrained resource. The TOC process identifies the constraint and helps to achieve the determined throughput is reached.
Goldratt’s philosophy has certain rules which are as follows:

1. Balancing Materials flow rather than balancing capacity leads to more efficient production management.
2. The level of resources utilisation at areas other than at production system bottlenecks is defined by system limitations and not the potential at the specific location.
3. Utilisation and activation of a resource are not synonymous.
4. An hour lost at a bottleneck is an hour lost for the entire system.
5. An hour saved at a non-bottleneck does not provide any value for the system.
6. Bottlenecks determine throughput as well as the level of inventory in the system.
7. The transport batch does not have and often should not be the same as the production batch.
8. The production batch should be variable over time along the entire production process schedule.
9. Production schedule should be created with respect to all limitations of the production system.
10. Lead times are a product of the schedule and cannot be established in advance.

(Goldratt, and Cox, J., 1992)

The benefits in applying TOC in a company according to Cargo Solutions (2012):

- Lead Times – Mean reduction of up to 70%
- Due date performance – mean improvement of 44%
- Inventory levels – mean reduction of 49%
- Revenue – mean increase of 63%.

In TOC implementation there is no ERP system that supports the concepts, according to Schragenheim, (2011). It is stated that the differentiation TOC makes between Planning and execution does not conform to ERP systems, ERP does planning, without full consideration of the uncertainty, and builds everything around it. ERP re-plans as much as necessary, the execution in TOC-Buffer management- means prioritising based on changing reality without re-planning. Buffer Management is reactive on what is happening in reality. Keeping a close eye on what is happening to the buffer at all times and when the buffer levels on average are low, more inventories are added.
2.1.1. Buffer Management in TOC

Buffer management is effectively using time buffers to manage and improve throughput. It provides information based on actual and planned performance. In a system where buffer management (operations strategy tool of TOC) is implemented, choosing the right buffer size in TOC is not a necessity if the inventory level is controlled and monitored correctly. This is not the optimum way to manage inventory. An excess amount of inventory might evolve which will then push up costs of the company. The size of the buffer level is dependent on the demand and supply of that specific item. Demand is the factor that affects the rate of depletion and supply is the rate at which the depleting item can be fulfilled (replenished) again.

There are two management approaches according to Yuan, Chang & Li (2003):

- Hold high levels of inventory in order to face peaks of demand and ensure availability
- Hold low inventory in order to cut expenses, to insure quality and reduce returns due to shelf life, changes and becoming obsolete.
To be able to monitor the inventory levels accurately, three issues need to be addressed, namely: How often should the inventory status be determined, when a replenishment order should be placed, and how large should the order be. (Yuan, Chang & Li (2003))

![Diagram](Image1)

**Figure 3: Dilemma of inventory management**

Source: Yuan, Chang & Li (2003)

Buffer management applies a type of heuristic method; this does not provide a continuous monitor approach to assist in the changing of demand. TOC buffer management has 3 objectives mentioned by Yuan, Chang & Li (2003) which are protecting throughput, reducing inventory and decreasing operating expenses. Sizing the buffer correctly with a safety factor of 1.5, this provides extra protection for unexpected demand.

Three controlled zones are used in buffer management: green, yellow and red. Each zone has one-third of the buffer. When the buffer is in the green zone, no action is needed. And if the buffer reaches the red zone—immediate action needs to be taken. This single focusing tool which will be used in a production plan is an advantage towards TOC.

If the buffer is too large, the level will always stay in green, and if too small, the level will be in the red zone. TOC claims that after several iterations the right level will be achieved.

TOC buffer management according to Yuan, Chang & Li (2003) is also used as a tool for reducing operating expenses. A higher buffer size decreases the need for emergency shipments. TOC is unfortunately not very rigorous. If wanting to implement TOC buffer management in the real world, a method is needed such as an ERP system. Theory of Constraints relies on forecast implicitly based on historical demands.
2.1.2. Dynamic Buffer Management

Dynamic buffer management is a principle to dynamically change the levels of buffers when required. The initial buffer levels are calculated with this formula:

\[
\text{Initial Buffer Size} = \text{ToC Replenishment Days} \times \text{Average Daily Use} \times \text{Variability Factor} \\
\times \text{Paranoia Factor}
\]

According to Cushing (2012).

ToC replenishment days is non-other than the lead time a product has from the replenishment order until the product has been manufactured and received by the warehouse.

The Paranoia factor will cover management’s concern of too high buffer levels or too low. This factor will vary with all types of products; this will be a high number if there is a frequent need for the product or not having that product will result in a major loss. A lower number will be used when the need for that product is low and failure to make the product available not that detrimental.

The Variability factor is like a safety factor and will be a high value when the demand variability is high.

Dynamic Buffer Management is used to monitor the levels of buffer by looking at a certain past time period of what has happened with respect to the stock on hand, replenishment supply and the consumption of a product.

With using buffer penetration (the ending buffer level divided by the initial buffer level) will categorise the product in the different colour zones as above in 2.1.1(prof this refers to the buffer management of TOC) the monitoring of the buffer levels is made simple.

Action will be taken with regards to the level of buffer for a certain subject when 3 consecutive periods are in the red zone, the buffer level for the next period will be increased by 20%. When a buffer levels penetration is in the green zone for four consecutive periods, the buffer level must be decreased by 20%.
2.2. Material Requirements Planning

ERP systems deploy a Manufacturing Resource Planning (MRPII) model, using time phased planning as well as bills of materials, the master production schedule information as well as dependant demand to identify materials needed for production. MRP provides forward visibility of material requirements, but is complex and requires a lot of data with high levels of accuracy. The strength of MRP comes from the ability to deal with uncertainty, complexity and variability (S. T. Enns 2001). The is a need for an accurate requirements plan for a manufacturing company to be successful in satisfying the customers demand as well as improving productivity and maximising the companies resource usage. In order for an MRP system to be successful in this, a few elements of the MRP system will be discussed and they are:

- Forecasting
- Dependant Demand
- Time Phased Planning
- Capacity Planning
- Economic Batching Quantity
- MPS Re-planning Frequency

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**Figure 4: Framework of manufacturing resources planning system**

Source: Vollman, Berry & Whybark
2.2.1. Forecasting

Forecasting is an estimation of the future demand that a company will come across, it is of great importance for the forecasting of products to be accurate to ensure that the production plan is correct to a certain degree that there is not a shortage or an oversupply of inventory.

Forecasts as well as sale orders are used to generate the gross requirement for the master production schedule which then is used in the MRP based ERP system. A master production schedule is a plan for production for end items. It breaks down the end item into the quantity that needs to be made in a certain time frame. The MPS is bound to change, reason being, the accuracy of the future forecast demand and the actual demand will be different. If the forecasting is incorrect it will have a direct effect on the MRP-ERP system. According to Yeung, Wong and Ma (1998) the quality of the MPS will directly affect the production efficiency on the shop floor, the inventory costs of the system and the customer service level. (Lee and Everett and Adam (1986))

2.2.2. Dependant Demand

Dependant demand is the demand of a product that is derived from another product. This demand can be calculated and is not needed to be forecasted. In MRP dependant demand provides the central foundation for priority planning. This could get very complicated if a manufacturing company has a product that has numerous components and each component needs to be derived from the dependability of the primary product demand. A problem arises when an order is put in for the primary product and is retracted, if the dependant demand of the components are not retracted as well the inventory levels might be of oversupply.

Safety stock is kept for the fluctuation in demand as well as for late deliveries. This could help in fixing the forecasting error. If the correct quantity of safety stock is used, reductions of costs are seen while too much safety stock increases the inventory costs.
2.2.3. Time Phased Planning

According to Enns (2001) in practice MRP planned lead time are set higher than necessary to cover for worst case scenarios. If this may be the case, it results in longer actual lead times and more orders being set out to compensate for the planned lead time.

Enns (2001) also states that time phased order releases are controlled by the planned lead times associated with each stage in the bill of materials.

2.2.4. Economic Batching Quantity

The most economic order quantity is calculated by taking into account the cost of handling inventory, the cost of processing a purchase order and the cost of set up. The larger the batch, the less flexibility there is to meet requirements, the larger the lead time and average stock holding. The larger the EBQ, costs are lowered for set up. To name a few lot sizing techniques that are used (1) Lot-for-Lot, (2) Fixed order Quantity, (3) fixed period quantity, and (4) economic order quantity.

Lot sizes vary from company to company; the lot size should be determined by taking the capacity-constrained assumption and the set up times.

2.2.5. MRP in a Syspro ERP-Environment

Syspro is an MRP based ERP system that links all departments of a company together, one of the modules in Syspro is called Requirements Planning that integrates Sales orders, quotations, work in progress, and bill of materials in order to find out what the material requirements are of the manufacturing company.

It is of great need for this requirements planning module to have an inventory forecast, sales orders, purchase orders and work in progress.

Integrations between modules are made, the inputs of the requirements plan are as follows: BOM (the demand for parent creates the demand for components (Dependant Demand)), quotations, work in progress (Operations create capacity requirements), inventory (which is the on-hand quantity and safety stock which balances supply with demand), inventory forecasts and sales orders.

An accurate requirements plan for a manufacturing company to be a success is needed in satisfying the customers demand as well as improving productivity and maximising the resource usage.
2.3. Case Study- TOC and MRP in practice

An opportunity was given to visit a factory in the Cape Town where the planning principles of TOC such as Drum-Buffer-Rope and buffer management is used to dynamically change the buffer sizes. The processes incorporate Syspro functionality with a strong human component in the form of a master planner as well as using a system called Symphony which allows Swartland to see all the past buffer penetrations and adjust the levels of buffers accordingly. Swartland only change their buffer levels when 3 or more consecutive previous time periods were in a red or green zone.

```
Dynamic Buffer Management

Material Planning  Production Planning  Distribution Planning  Sales Budgeting
Buy  Make  Move  Sell

Purchasing Control  Production Control  Distribution Control  Sales Control

Performance & Financial Measurements
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Source: iPlan

The High Level Business Process Model above is what Swartland adhere to; Dynamic Buffer Management will play a key part in the design of the Buffer Monitoring Dashboard.

This factory has a so-called buffer penetration dashboard, when there is 100% buffer penetration; the buffer level is in the black zone if no buffer is available.

Swartland have inventory buffers as seen in the above generic diagram namely: finished products, Sub-assemblies and raw materials buffer. A make to stock approach is taken, there is a central warehouse where all products are delivered to and from there, and distributions to various customers and warehouses country wide are made.

The demand for the Material Requirements planning run is based on the level of buffer (Safety stock), actual sales orders, jobs and purchase orders. The dependant demand is calculated by the Bill of Material for each product demand. The available stock is the actual stock less those already allocated to sales orders and works orders.
A visualisation of how TOC philosophy is implemented in the factory with respect to the critically constrained resources. An alarm will be sounded as well as a robot system will be lit red when the process for some reason has stopped.

After the visit a clearer understanding toward Theory of Constraints principles was established such as:

- How TOC works in practice with the help of a MRP based ERP system,
- How TOC states that the concentration of the process need be on the critical constrained resource which will determine the heart beat (production rate) of the process.
- How dynamic buffer management work.
- There is still a need for human intervention when changing the buffer levels.
2.4. Key Findings from Literature Review

A system is needed that identifies capacity constraints and helps maintain the optimal stock holdings in warehouses as well as work in progress areas that will create a realistic purchasing and production schedule.

TOC and the buffer penetration principle is used in practice where one needs to dynamically change the buffer size to minimise out of stock cases as well as reduce the amount of inventories.

According to dynamic buffer management as discussed in Chapter 2 the buffer penetration is calculated (Current Stock available divided by the Initial Buffer level) and is given a colour code. If the buffer penetration is in the Red Zone for three consecutive periods prior to the current time period, the buffer level needs to be increased by a third and a replenishment order is released, in turn, if in the green zone for more than 4 time periods, the buffer level will be decreased.

In support of the above TOC, MRP introduces Time Phased Planning and forecasting where the projected demand and supply can be determined. Using data from an MRP based ERP system, this time phase planning can be incorporated into a projected buffer penetration calculation. Not only will this help in planning for production but also introduces forward planning of production priorities. This will enable the production planner to see whether the process has the capacity to produce the needed products as well as increasing the buffer level when 3 consecutive future time periods are in the red zone.

This projected buffer monitoring dashboard will be a key identifier as to whether the initial buffer size calculated is approximately correct.

Based on the above, two models were built. One is based on only the current period, current stock level and buffer levels. The other will incorporate the demand and supply taken from the Time Phased Planning of MRP. This will be a buffer monitoring dashboard with the projected buffer penetration for a defined planning horizon.
3. Requirements Analysis of the Production Planning Dashboard

Two buffer monitoring dashboards were developed; one considering only the quantity on hand of the products in the warehouses. The other will consider the MRP principle – Time Phased planning and incorporate that into a buffer monitoring dashboard with variables such as the planned quantity demand and the planned supply for a certain time period. A dashboard is defined as a user interface that has all the relevant information needed. An entity relationship diagram was used to understand what data will be used and needed, as well as the relationship of the different entities.

The functional requirements below are related to both dashboards.
3.1. Swim lane Diagram for a Buffer Monitoring System

Swimlane Diagram of the Buffer Monitoring Dashboard

Syspro

Production Planner

Buffer Monitoring Dashboard

Phase

Receive Data from Syspro in .xls format

Calculate Initial Buffer Levels

Generate Pivot Chart

Are there Black products?

Fill up buffer levels when capacity is available

No

Are there 4 consecutive periods in the Green Zone?

Increase the buffer level by 20% and Replenish

Yes

Buffer level acceptable

Are there 3 consecutive periods in the Red Zone?

Decrease the buffer level by 20%
The swim lane diagram above illustrates the data flowing in from the ERP System Syspro as well as how to determine the necessity to increase or decrease the buffer levels. This shows the sequence of steps that will be followed and ultimately the need for a new buffer level can be determined.

3.2. Entity Relationship Diagram

As explained above the ERD represents the data and variables the Buffer Monitoring system needs to take into account. An ERD helps identify the relationship between each variable.

3.3. Functional Requirements

The primary functional requirement is to determine whether the initial calculated buffer is correct. When the buffer level is correct, the replenishment orders will be made up and until that level of buffer. When the buffer is determined to be incorrect, too high or too low, a correction must be made by increasing or decreasing the buffer level by 20%. With a projected Buffer Monitoring Dashboard, the production planner will be able to see when the initial buffer level is too high or too low and adjust accordingly.

Buffer penetration is calculated by deducting the current stock on hand. With the new improvement to buffer monitoring, an addition to the buffer penetration calculation would be to deduct the supply and add the demand. 100% buffer penetration means that the products are depleted and zero stock is available, whereas 0% means that the buffer has not been penetrated and the stock is at the top level of the buffer level.
Sorting the buffer penetration of each product code into a colour coded zones, the replenishment priority for these products will be made visible to the production planner. In the projected buffer monitoring dashboard three consecutive periods of the red zone will allocate that the buffer level is too low. Four consecutive green zones allocates that the buffer is too high, therefore it can be lowered. A black zone will evolve in the second dashboard which will then take priority, this will be an indication that the buffer of that period is far too low and needs to be set higher. The black zone appears when there is a far too high demand for a certain product and the buffer penetration is above 100%, meaning there is a backlog of products that need to be made that the current supply and stock on hand cannot resolve. If this product is black in the current period, a replenishment order will need to be made as soon as the production capacity allows it. Red zoned products will be between zero and a third of the buffer level (67% - 100% buffer penetration) and will follow the same rule of three consecutive periods in the red zone means a too low buffer. Yellow zoned products will be between one third and two thirds of the needed buffer level and green zone will be between two thirds and the buffer level maximum.

A mandatory requirement would be to generate a graphical representation of the products that are categorised in the colour zones, the red zone being the highest priority or in the case of the second buffer monitoring dashboard the black zone, which needs replenishment and buffer adjustment.

The ideal function in a buffer monitoring dashboard would be the ability to ‘Click’ on the relevant bar in the graph to see the individual products and buffer penetrations in order to create a replenishment order for that specific product to lift the buffer level or merely until the buffer level. Excel does not have this function; however iPlan’s development team would be able to design this function in their final model.

3.3.1. Non-Functional Requirements
The non-functional requirements that will play an immense part in order for buffer monitoring dashboard to be as efficient as possible, the data received from Syspro has to be accurate and in the first dashboard the data is needed as current as possible. This will allow the inventory levels to be kept at the correct levels which would directly decrease costs and obsolesces.
4. Process Blueprint of a Buffer Monitoring Dashboard

Data was taken from Syspro, where a model in Excel was developed that implemented buffer penetration in terms of buffer management based on TOC. The calculations of buffer penetration (taken from Buffer Management and iPlan) were calculated and with this, a pivot chart was developed in order to distinguish which product is penetrated by what percentage.

The intention of this would be to see how TOC buffer management essentially works with raw current data received from Syspro.

4.1. Required pre-conditions

The data from Syspro will be needed in the following format:

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Code</td>
<td>Text</td>
<td>This defines the type of product stored in the warehouse</td>
</tr>
<tr>
<td>Warehouse</td>
<td>Text</td>
<td>This defines in what warehouse that specific stock code is</td>
</tr>
<tr>
<td>Quantity On Hand</td>
<td>Number</td>
<td>This is the amount of on hand stock available for a specific stock code at a specific warehouse</td>
</tr>
<tr>
<td>Buffer</td>
<td>Number</td>
<td>This is the amount that the specific products level of inventory needs to be</td>
</tr>
</tbody>
</table>

It is assumed that this buffer field is the initial calculated buffer using the formula that was given by (Cushing, 2012) before entering into the Excel Data sheet.

4.2. Considering the primary TOC Principle: Buffer Management

When looking at the principle Buffer management based on TOC, the variables that are considered in calculating the buffer penetration are only the current stock on hand and then the proposed buffer level.
4.2.1. Buffer Penetration Logic

Buffer penetration, calculates the percentage that the buffer level is penetrated by. Of the buffer level, what quantity of goods is available and what needs to be replenished. A simple formula to manage the buffer follows:

\[
\text{Buffer - Stock On Hand} \times 100
\]

\[
\frac{\text{Buffer}}{\text{Buffer - Stock On Hand}} \times 100
\]

The colour zones will be as follows:

![Defining Zones](image)

Figure 6: Defining Colour Zones for Buffer penetration
4.3. Analysis of TOC buffer Penetration and Quantity On hand

A model was set up in Excel with the data from Syspro. With this data, the buffer penetration is calculated using the above mentioned formula; colour codes will be allocated to the various products with the following Excel Formula:

\[
IF(AND(67 < "Buffer Penetration","Buffer Penetration" < 100),"RED",IF(AND("Buffer Penetration" > 33, F4 < 67),"YELLOW", IF("Buffer Penetration" <= 33, "GREEN", "BLACK"))
\]

Below is an example of how the data will be given in Excel as well as the calculation of the buffer penetrations and colour zones:

Table 2: Example of Data in Excel

<table>
<thead>
<tr>
<th>StockCode</th>
<th>Warehouse</th>
<th>QtyOnHand</th>
<th>Buffer</th>
<th>Buffer Penetration</th>
<th>Colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>260SKELETJAM</td>
<td>PF</td>
<td>14</td>
<td>15</td>
<td>7</td>
<td>GREEN</td>
</tr>
<tr>
<td>260SKELETJAM</td>
<td>RF</td>
<td>6</td>
<td>12</td>
<td>50</td>
<td>YELLOW</td>
</tr>
<tr>
<td>70ARCHITRAVE</td>
<td>PF</td>
<td>16</td>
<td>18</td>
<td>11</td>
<td>GREEN</td>
</tr>
<tr>
<td>BSHRZFS2</td>
<td>PF</td>
<td>145</td>
<td>300</td>
<td>52</td>
<td>YELLOW</td>
</tr>
<tr>
<td>BSHRZMS2</td>
<td>RF</td>
<td>41</td>
<td>45</td>
<td>9</td>
<td>GREEN</td>
</tr>
<tr>
<td>BSHRZMS2</td>
<td>SF</td>
<td>11</td>
<td>12</td>
<td>8</td>
<td>GREEN</td>
</tr>
<tr>
<td>BSHRZMS2</td>
<td>TF</td>
<td>18</td>
<td>17</td>
<td>0</td>
<td>GREEN</td>
</tr>
<tr>
<td>BSMLDM0</td>
<td>SF</td>
<td>12</td>
<td>15</td>
<td>20</td>
<td>GREEN</td>
</tr>
<tr>
<td>BSSBTMS0HS</td>
<td>SF</td>
<td>10</td>
<td>12</td>
<td>17</td>
<td>GREEN</td>
</tr>
<tr>
<td>CATSTAND</td>
<td>PP</td>
<td>13</td>
<td>50</td>
<td>74</td>
<td>RED</td>
</tr>
<tr>
<td>CBSTDLO12062</td>
<td>RF</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>GREEN</td>
</tr>
<tr>
<td>CBSTDLO15114</td>
<td>RF</td>
<td>20</td>
<td>80</td>
<td>75</td>
<td>RED</td>
</tr>
<tr>
<td>CCDLS</td>
<td>PP</td>
<td>2</td>
<td>90</td>
<td>98</td>
<td>RED</td>
</tr>
</tbody>
</table>
4.3.1. Construction of the Graphical outputs

The best way to monitor the buffer levels is to do it graphically. A graph can be used by the production planner to see how many products in a specific warehouse are in need of replenishment in the current state. As well as see whether the buffer level is satisfactory and accurate.

The amount of data that was given to do an analysis with was plentiful and a way was needed to be to graph all of the data into a summary for this monitoring system. Through trial and error the method in Excel that would best suite this type of data would be by use of a pivot chart.

A pivot chart condenses great amounts of data, filtering of data is made easy with a pivot chart which is ideal in the case of a buffer monitoring dashboard tool as one would like to choose which warehouse, product or colour zone and then analyse. The specific pivot chart chosen for the graphical outputs will count within each warehouse how many products are in zone green, yellow and red currently. This will give the production specialist an idea of where the buffer levels are accurate or lacking.
4.3.2. Screen Layouts of the Graph

Figure 7: Graphical Output Logic

<table>
<thead>
<tr>
<th>Index</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Filters data according to the stock code</td>
</tr>
<tr>
<td>2</td>
<td>Filters to a specific colour zone</td>
</tr>
<tr>
<td>3</td>
<td>Count of colour zoned products</td>
</tr>
<tr>
<td>4</td>
<td>Filters data to a specific warehouse</td>
</tr>
<tr>
<td>5</td>
<td>Warehouse with all their colour zoned products</td>
</tr>
</tbody>
</table>
The above graph will be the dashboard when only looking at the current stock on hand. The numbering on the graph and related table indicates what each filter can do.

What a production planner would ideally want to see is the amount of red products per warehouse in order to analyse the buffer levels and send out a replenishment order for that product, the graphs that follow illustrate how one can filter until only the red products are shown:

Figure 8: Filtering Data on Graphs

Click on relevant colour, in this case RED and click OK
Figure 9: Choosing RED zone

Figure 9 shows when clicking on the filter for the different colours, the colours pop up and one can be chosen, in this case, the red zone will be chosen.

Figure 10: Graph with RED Zone

Considering Figure 10, this can be used as a buffer monitoring dashboard where it will concentrate on only the red zoned product. This will give the production planner an idea of the current status of the warehouses. At the moment the graph illustrates the amount of
products that are in the red zone. The percentage buffer penetration for each product might need to be visible to the planner. Although the above graph solves the problem of having a single summarised view; more development is needed concerning this issue. iPlan can take this and further develop this model by enabling a requirement of when a red bar in the graph is selected, a pop up screen of the products that are summarised in that bar appears with the necessary information of the buffer penetration, buffer levels, etc. Buffer penetration allows the production planner to see exactly how full the buffer is in the system. 100% buffer penetration is a bigger priority than 67%. If the buffer penetration percentage is known, the priority for a replenishment order can be established.
5. Process Blueprint of a Projected Buffer Monitoring Dashboard

A model was developed in Excel that integrated TOC buffer management as above with time phased forward planning. The formula for buffer penetration was altered to incorporate the projected buffer based on expected or planned future demand and supply of a product. The same steps were followed as in the Process Blueprint of a Buffer Monitoring Dashboard in the previous chapter.

This dashboard is different to Chapter 4, with regard to the period of time. The projected buffer penetration is now visible in the dashboard which will improve proactive planning and prioritisation. This dashboard is an addition to the first dashboard, where the principles of Dynamic Buffer Management are used.

As mentioned previously, one can now see whether an initial calculated buffer will be sufficient for the projected demand and supply. When the buffer penetration is in the red zone for 3 consecutive times, the initial buffer level is not high enough. An adjustment of 20% can be made. When the buffer penetration is in the green zone 4 consecutive times, the buffer level allocated is too high and would be lowered by 20%.

5.1. Required pre-conditions

The data from Syspro will be needed in the following format:

Table 3: Table Format in Excel

<table>
<thead>
<tr>
<th>Field</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stock Code</td>
<td>Text</td>
<td>This defines the type of product stored in the warehouse</td>
</tr>
<tr>
<td>Warehouse</td>
<td>Text</td>
<td>This defines in what warehouse that specific stock code is</td>
</tr>
<tr>
<td>Quantity On Hand</td>
<td>Number</td>
<td>This is the amount of on hand stock available for a specific stock code at a specific warehouse</td>
</tr>
<tr>
<td>Quantity Allocated</td>
<td>Number</td>
<td>This is the demand expected for a specific time period</td>
</tr>
<tr>
<td>Quantity On Order</td>
<td>Number</td>
<td>This is the expected replenishment for a specific time period (Supply)</td>
</tr>
<tr>
<td>Buffer</td>
<td>Number</td>
<td>This is the amount that the specific products level of inventory needs to be</td>
</tr>
<tr>
<td>Time Phase</td>
<td>Date</td>
<td>This is the expected time period as to which the demand and supply orders be fulfilled</td>
</tr>
</tbody>
</table>
Once again the buffer given by Syspro is assumed for this Excel model that the initial calculated buffer was calculated using this formula:

\[
\text{Initial Buffer Size} = \text{ToC Replenishment Days} \times \text{Average Daily Use} \times \text{Variability Factor} \times \text{Paranoia Factor}
\]

5.2. Considering the principle: Buffer Management
Two key principles namely Dynamic Buffer Management and Time Phased planning were evident from literature. In order to incorporate these two principles a dashboard was developed that not only the current buffer penetration be visible but also the futures. For this model the supply and demands of the products were taken into account. With this model it can be seen that buffer management can not only be used for the current time period but also for the future forecasted demand and supply. This allows the production planner to plan ahead if there is available capacity to do so.

5.2.1. Buffer Penetration Logic including Demand and Supply
The buffer penetration once again calculates the percentage that the buffer is penetrated by, what quantity of goods is available and what needs to be replenished. A simple formula follows for the current buffer penetration:

\[
\frac{\text{Buffer} - \text{Stock On Hand}}{\text{Buffer}} \times 100
\]

For the buffer penetration formula of the next time phase will be as follows:

\[
\frac{\text{Buffer} - (\text{Stock On Hand}(t+1) + \text{Quantity on Order}(t+1) - \text{Quantity Allocated}(t+1))}{\text{Buffer}} \times 100
\]

Where the Stock On Hand(t+1) will be calculated using the following formula:

\[
\text{Stock On Hand}(t) + \text{Quantity on Order}(t) - \text{Quantity Allocated}(t)
\]
The colour zones will be as follows:

![Defining Zones](image)

**Figure 11: Defining the Colour Zones for MRP-TOC Model**

The reason for having a black zone is since demand and supply have been introduced to the equation, more than 100% buffer penetration can be possible as it merely means that the amount of supply is not enough to cover that products’ demand. The cause of this could be the buffer level is too low. This product will then need immediate attention.

5.2.2. Analysis of TOC buffer Penetration, Quantity On hand, Supply and Demand

A model was set up in Excel with the data from Syspro. With this data, the buffer penetration can be calculated using the above mentioned formula; this will then be put into the different colour zones using this formula on Excel:

\[
IF(AND(67 < "Buffer Penatration","Buffer Penatration" <= 100),"RED",IF(AND("Buffer Penatration" > 33, F4 <= 67),"YELLOW",IF("Buffer Penatration" <= 33,"GREEN","BLACK")))
\]

The black will now indicated that the buffer penetration is more than 100%, as there might be a future demand for the product but not a supply. The production planner would need to make this colour zone the priority product and thereafter the red zone will take priority.
Below is an example of how the data is presented in Excel as well as the calculation of the buffer penetrations and colour zones:

Table 4: Example of Data in Excel

<table>
<thead>
<tr>
<th>StockCode</th>
<th>Warehouse</th>
<th>QtyOnHand</th>
<th>Buffer</th>
<th>QtyAllocated (DEMAND)</th>
<th>QtyOnOrder(Supply)</th>
<th>Buffer Penetration</th>
<th>Colour</th>
<th>Time Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>260SKELETJAM</td>
<td>PF</td>
<td>14</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>260SKELETJAM</td>
<td>RF</td>
<td>6</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>50</td>
<td>YELLOW</td>
<td>Current</td>
</tr>
<tr>
<td>70ARCHITRAVE</td>
<td>PF</td>
<td>16</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>11</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>BSHRZFS2</td>
<td>PF</td>
<td>145</td>
<td>300</td>
<td>50</td>
<td>0</td>
<td>68</td>
<td>RED</td>
<td>Current</td>
</tr>
<tr>
<td>BSHRZMS2</td>
<td>RF</td>
<td>41</td>
<td>45</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>BSHRZMS2</td>
<td>SF</td>
<td>11</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>BSHRZMS2</td>
<td>TF</td>
<td>18</td>
<td>18</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>BSHRZMS2</td>
<td>SF</td>
<td>12</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>BSHRZMS2</td>
<td>SF</td>
<td>10</td>
<td>12</td>
<td>9</td>
<td>1</td>
<td>83</td>
<td>RED</td>
<td>Current</td>
</tr>
<tr>
<td>CATSTAND</td>
<td>PP</td>
<td>13</td>
<td>50</td>
<td>0</td>
<td>50</td>
<td>26</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>CBSTDLI012062</td>
<td>RF</td>
<td>15</td>
<td>20</td>
<td>15</td>
<td>0</td>
<td>100</td>
<td>RED</td>
<td>Current</td>
</tr>
<tr>
<td>CBSTDLI015114</td>
<td>RF</td>
<td>20</td>
<td>80</td>
<td>20</td>
<td>0</td>
<td>100</td>
<td>RED</td>
<td>Current</td>
</tr>
<tr>
<td>CDEL5</td>
<td>PP</td>
<td>2</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>98</td>
<td>RED</td>
<td>Current</td>
</tr>
<tr>
<td>CDBFLH50</td>
<td>RF</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>CDBFLH50</td>
<td>SF</td>
<td>6</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>CDELPH50</td>
<td>TF</td>
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<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>CDSPNH50</td>
<td>PF</td>
<td>193</td>
<td>340</td>
<td>4</td>
<td>33</td>
<td>35</td>
<td>YELLOW</td>
<td>Current</td>
</tr>
<tr>
<td>COL-HRO1.8HX3.0D</td>
<td>PK</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>60</td>
<td>YELLOW</td>
<td>Current</td>
</tr>
<tr>
<td>COL-HRO2.4HX3.0D</td>
<td>PK</td>
<td>1</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>95</td>
<td>RED</td>
<td>Current</td>
</tr>
<tr>
<td>COM008</td>
<td>PF</td>
<td>98</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>GREEN</td>
<td>Current</td>
</tr>
<tr>
<td>COM008</td>
<td>RF</td>
<td>5</td>
<td>60</td>
<td>0</td>
<td>0</td>
<td>92</td>
<td>RED</td>
<td>Current</td>
</tr>
<tr>
<td>COM022</td>
<td>RF</td>
<td>17</td>
<td>50</td>
<td>0</td>
<td>0</td>
<td>66</td>
<td>YELLOW</td>
<td>Current</td>
</tr>
<tr>
<td>COM057</td>
<td>PF</td>
<td>5</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>75</td>
<td>RED</td>
<td>Current</td>
</tr>
</tbody>
</table>
5.2.3. Construction of the Graphical outputs

The same method will be followed as the above chapter 4; unfortunately the amounts of warehouses as well as the time periods make it very hard to use this pivot chart as a single focusing tool. Before using this graph for analysis, filtering to a specific warehouse will enable an enhanced buffer monitoring dashboard.

This pivot chart still counts within each warehouse the amount of products that are in the green, yellow, red and now black zones within the specific time periods.
5.2.4. Screen Layouts of the Graph

<table>
<thead>
<tr>
<th>Index</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Filters data according to the stock code</td>
</tr>
<tr>
<td>2</td>
<td>Filters to a specific colour zone</td>
</tr>
<tr>
<td>3</td>
<td>Count of colour zoned products</td>
</tr>
<tr>
<td>4</td>
<td>Filters data to a specific warehouse</td>
</tr>
<tr>
<td>5</td>
<td>Warehouse with all their colour zoned products at the specified Time Phases</td>
</tr>
<tr>
<td>6</td>
<td>Filters data according to the Time Phases</td>
</tr>
</tbody>
</table>

Figure 12: Graphical Output Logic
The above figure illustrates all the time periods and warehouses, in order for it to become a buffer monitoring dashboard filtering of the data is needed.

![Figure 13: Filtering Data on Graph](image)

Clicking on relevant colour, in this case RED and BLACK. This will allow the production planner identify which buffer levels are going to be too low. One can also choose the Green zone to see whether the initial buffer level that was calculated is too high.
Filtering of this graph to make the priority colour zones more visible is shown below:

Figure 14: Filtered Graph according to Colour Zones

Figure 14 above is still not clear enough to identify where the initial buffer level is too high or low. Further filtering is needed such as selecting specific warehouses.

Figure 15: Filtered Graph according to specific warehouses

The specific warehouse that the production planner would like to focus on can be chosen.
Figure 16: Filtered Graph ready for analysis

Figure 16 above can be used to see whether the initial buffer level is correct or close to correct. Three consecutive red zoned periods noted here will give the production planner an idea as to when his buffer level will be too low and that it will be in need of an increase of 20%. This is the concluding outcome for this project.

This illustrates that the principle of buffer management can be used not only for current stock levels, but also for projected time periods for the planning horizon for demand and supply. This allows for time phased planning (MRP principle), if there is capacity available to manufacture more products, this buffer monitoring dashboard will establish which product will be in the black or red zone in the future. And the buffer levels can be changed accordingly.
6. Dashboard Selection

With the two buffer monitoring dashboards developed, the use of each will come into play with different environments. Some factors to consider when choosing a certain buffer monitoring system:

- The type of environment
- Type of demand; Stable or dynamic
- Product Type and obsolescence
- Cost of product
- Production capacity
- Inventory capacity

The type of demand will have a definite impact of choice. In a dynamic demand environment, planning ahead and getting the initial buffer levels and future levels accurate is a great necessity to eliminate stock outs. The second buffer monitoring system will be ideal as one can see the projected demand and then analyse whether the current buffer level is suited.

A high buffer level for a product that will gain obsolescence if on the shelf is not ideal. The current stock buffer monitoring dashboard will be sufficient in this case.

In both dashboards the production capacity plays a major role, if there isn’t capacity to increase the buffer level or merely fill the initial buffer level a problem will arise that top management would have to take care of.

The more expensive the product is, the more accurate the buffer level needs to be. The second buffer monitoring dashboard will aid in achieving a more accurate buffer level which will also result in a faster inventory turnover.

The less inventory space a warehouse has, the more accurate the buffer level will need to be. Wasted space (too high buffer level of a certain product) creates less space for a product that might need a higher buffer level but is unable to as a result of an unnecessary high buffer level of another product.

In conclusion buffer management and dynamic buffer management can be used not only with past data and past buffer penetrations but also with a projection into the future. This will assist with production planning; reducing obsolescence and unnecessarily high buffer levels and the accuracy of a replenishment order sent through to Syspro to fill up the buffer level.
The concept of the projected buffer monitoring dashboard incorporates not only a buffer management principle but also added time phased planning from MRP and a projected buffer monitoring dashboard was developed.

This will be beneficial for a company who has an MRP-based ERP system in place as well as combine buffer management in their production planning.
7. References


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VOLLMANN, T., BERRY, W., AND WHYBARK, D., (1992), Manufacturing Planning and Control Systems (Homewood, IL: Irwin)