Overage Inventory – How does it occur and why is it important?

Peter Barrar and Geoff Relph.

Manchester Business School, Booth Street West, Manchester, M15 6PB, UK

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Abstract

Well-planned inventory is important to the successful operation of most healthy businesses. What this means, is that planning needs to be carried out to deal with three conditions;

- The possibility of too little inventory due to uncertainty, (Safety Stock)
- The replenishment of the inventory cycle due to depletion through normal demand (Cycle Stock),
- The probability of overage - or too much inventory, when assessed against planned levels.

The consequences for businesses are important at both item level and in the aggregate. At the item level, the inability to supply can have dire consequences for customer service and at the aggregate inventory level, for the operational, cash flow and working capital requirements of the business.

The paper argues that overage is important because there is evidence that, even in well managed businesses a significant proportion of the inventory is in overage at any given time. Evaluations of twenty-inventory profiles from companies in different business sectors show between 10% and 98% of the inventory values were 'in overage'. For most businesses this will not be a trivial amount and any actions that can reduce it will bring significant benefit. The paper concludes that overage should be recognised in the same way as safety stock and thus, formally planned. Hence the effective control of overage will enhance the business's profitability by minimising the inventory investment.

Introduction

The paper will review the issue of planning and control of inventories, briefly addressing the issues of safety and cycle stocks, and will then consider the issue of overage. The paper will describe what overage is, how it occurs and some ideas as to how it might be measured and therefore planned. The paper draws on previous research into safety and cycle stocks and the early stages of doctoral research on overage by one of the authors.

The issue of planning and control

The planning and control of inventory is an ongoing source of research opportunities, it has focused on planning for failure of supply using safety stocks and the capability of manufacturing to reduce batch sizes through lot size analysis. The area that appears to have received little attention is the subject of excess inventory. Shah (1992) used the term Overage in his classification of when describing excess inventory. In this paper, it will be used to describe excess inventory in the context of planned inventory levels.

There are many accepted arguments for the need to plan inventory, in particular safety stock and appropriate batching rules. However, the argument for including overage in the planning process has not been well articulated. We may consider an example; management set an objective to achieve a plan of £1 million of inventory and this is then acted upon by the planners. The planners implement this by setting the parameters of the planning and control system to achieve this business objective. If the possibility of overage is ignored then there is a high probability that this plan will be exceeded. If however overage was considered in the planning process, to achieve the same plan of £1 million the parameters would need to be set lower (Figure 1a & b) giving more aggressive operational targets for batch quantity, safety stock and lead-time in the business. The resulting plan would then have a lower probability of being exceeded and thus demand less reactive attention from management.

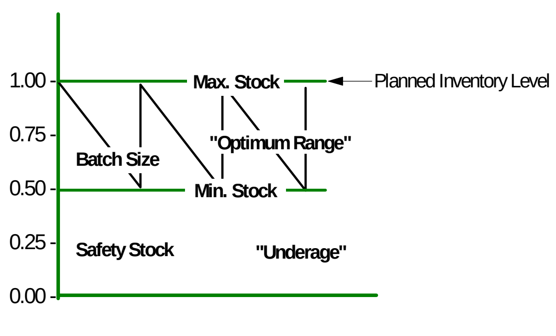

Figure 1a - Classic inventory "saw-tooth" – Plan to Maximum Stock

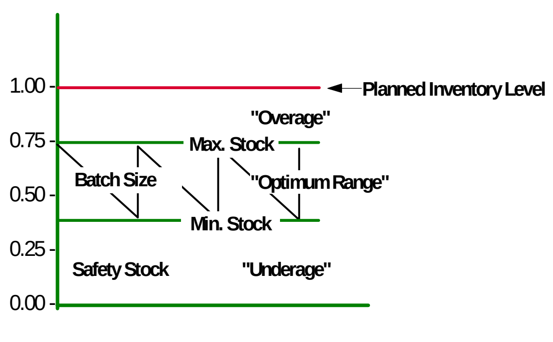

Figure 1b - Inventory plan to including overage

Shah (1992) discusses the practice of including overage in inventory planning in his thesis. But this paper goes further in considering the identification of overage as an additional business measure that has the potential to focus management attention on the causes of excess inventories. Therefore to more effectively plan and control

inventory, in addition to safety stock and cycle stock, we will consider whether overage should be considered in equal part.
The issue of too little inventory (shortages) is normally managed through the maintenance of safety stocks. Safety stock planning has been well researched by Silver (1998) and Brown (1982) amongst many others. Many workers, including Wilson (1934) and Shah (1992) have also researched the effective management of manufacturing cycle stock - the process that replaces what has been depleted by normal demand.

However, there has been little research carried out on the management and planning of too much inventory (overage). Too much inventory can have significant effects on the viability and performance of a business and on the effective utilisation of its resources. Businesses and business systems tend to plan on the assumption that the plan will be achieved. But inevitably, when the plan is exceeded, often accompanied by an unbalanced portfolio and poor customer service levels, additional (reactive) planning and management time is spent in trying to recover.

Overage

In the context of this paper overage is any inventory above the maximum planned stock levels. In all organisations when inventory plans are executed and exceeded, management attention turns to how to bring the inventory back to the original plan. Both Bocking (1996) and Hadley (1999) demonstrate that the introduction of the concept into the planning activity and taking into account an expected level of overage in operational plans can have a positive effect. Hence, the identification of overage as an additional business measure may well have the potential to focus management attention on the causes of excess inventories.

Overage a more detailed look

In order to plan to take account of overage we should look at its possible causes to identify if we can provide predictive techniques to assist in the planning process.

How overage occurs

The actions that are needed to achieve a particular inventory plan are made on the basis of a number of assumptions. If these assumptions change then there will need to be an adjustment to the plan, this adjustment is normally executed through the operation of the enterprise business systems. In using these systems, typically MRP based, there is an implicit assumption that all the adjustments suggested will be actioned. However, we know that this is not always the case.
To illustrate the point let us consider an example where the demand for a product falls as a result of the release of a new product. Within the new product, a key component abc is used which replaces component xyz in the old product. The business system will see the fall in the forecast requirements for the component xyz and make suggestions to the planner to re-schedule out the orders to maintain the maximum stock see Figure 2. The planner in most cases will execute the suggestions to re-schedule out the materials and the inventory will track along the maximum stock. If however, the planner chooses to ignore the instructions, the orders will be fulfilled and the inventory will rise above maximum into ‘overage’. The planner may have chosen not to process the orders for valid reasons, such as knowledge of a special last minute demand. It may also be due to the need to prioritise, such that he/she was not able to process the suggestions in time to prevent the supply. From this we can begin

to see possible causal factors for overage, firstly the adjustment to the change and the secondly the failure to take corrective action. The adjustment changes the original assumption such that inventory that was within plan is now considered to be in excess.

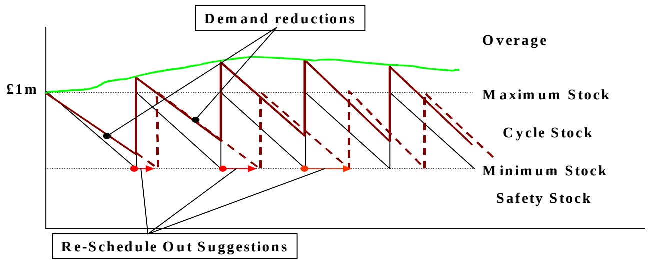

Figure 2 How Overage is created

Enterprise business systems use defined rules or algorithms to make suggested changes to inventory levels and adjustments are entirely dependant on the rules set and the operation of the system. Such changes necessarily rely on human intervention to put them into effect. If no action is taken outcomes will be non-compliant and will cause overage to occur as materials arrive to the original plan.

Adjustments

In the previous paragraph we suggested that if the assumptions change then an adjustment would need to be made. There are a number of factors that cause changes to the assumptions, which will create the need for adjustments, these factors include:

- Independent events – This is where materials are lost and then subsequently found or materials that have been identified as reject are subject to concessions and returned as good stock. These types of adjustments can also result from poor system synchronisation where stock movements are not correctly processed and result in stock being ‘lost and found’.
- Demand evolution – This occurs during the business cycle and can, in certain cases, create over-supply. For example at the beginning of the year, sales plans are high and may be adjusted downwards during the year to reflect actual performance and reduced expectations. There is a good illustrative example in the paper by Bocking (1996). Manufacturing knows that they must never restrict customer sales so they provision for the maximum projected volumes. As the volume is adjusted downwards the business system will need to follow by making suggested changes to the planned supply of materials.
- Product Phase In/Out - Similarly with new products being introduced and older products being phased out, the obsolete products are not always run down until the new product is established. If the new product is received well by the market and demand is high, the obsolete product demand could fall faster that planned. Also with new products there may be low initial process yields, which improve as the product matures. This will mean that the yield rates assumed by the system may vary and will need manual adjustment to take account of a significant improvement.

- Worst case and not 'most likely' lead-time assumptions, this leads to a higher probability that materials arrive earlier that planned by the system.

Suppression of adjustments

Enterprise business systems are 'rules based' and some systems may have rules that can prevent the suggested adjustment being applied. This is because it may not always be good business practice or practical to put an adjustment into effect. There are two main suppression mechanisms used; damping and time fences.

- Damping of adjustments is used to manage the amount of output because the business system calculates all adjustments irrespective of how small they may be in terms of order value or number of day's re-scheduled. It treats all possible changes as having the same priority or business value. For example a business system will suggest that to achieve the correct plan an order be re-scheduled by one day. This is clearly not practical and it would be useful to stop these suggestions being made. Thus the business system is given rules that will reduce the number of suggested changes that are generated.
- Time-fences are used to suppress the adjustment of imminent deliveries. This is because the business system calculates all the adjustments to plan irrespective of how close the next delivery may be. It may also not be practical to reschedule an order that is only (say 5) days before delivery is due.

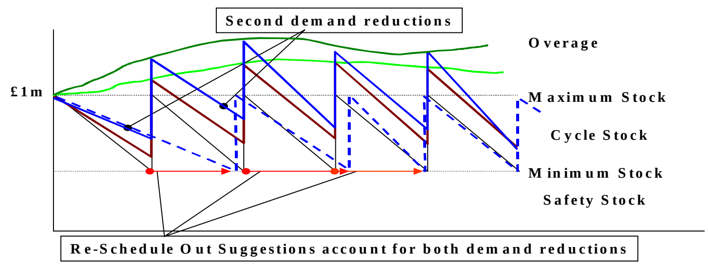

Figure 3 The cumulative effect in Overage creation

Compliance / Non Compliance

In terms of system use, we can loosely define compliance as being where the suggested adjustments generated by the business system are put into effect without any amendment. In many large enterprises with complex product structures the number of suggested changes are so many that they cannot all be put into effect by the resource that is available. As a result the suggestions are often prioritised, the logical priority is first to place new orders and re-schedule material that is needed sooner then previously planned, if this is not done then there is the possibility that production and customer service will be put at risk. The second priority will be the cancellation of material that is no longer required, if it is not cancelled the material will arrive and have to be put into stock, returned or scrapped. The lowest priority will be the re-scheduling out of material, as it does not put at risk production or customer service. It will also ultimately be used, however it will arrive early, have to be stored and funded for longer than planned.

There is a cumulative effect on overage of non-compliance and this can be illustrated if we consider our new product example. If the first adjustment of component xyz, Figure 3 is not acted upon and there is a second reduction of demand then the next suggested adjustments will attempt to correct for both the first and second demand reductions. This can be seen in Figure 3, which shows the effect of a second fall in the demand of component xyz. If this second adjustment is ignored then the overage that results is the cumulative effect of the two adjustments.

How it might be measured

The value of a company's overage or excess inventory can be significant. Hadley (1999), found that in his enterprise there was 41% overage inventory. Table 1 shows data gathered by one of the authors gained from many years working as an inventory consultant, this suggests that it may not be unusual for companies to carry between 10% and 98% overage. Clearly this is very significant and the implications for the effective planning and control are compelling.

Type of Business	% Value in Overage	Correlation between Annual Usage and Overage	Correlation between Annual Usage and Overage days	Correlation between Overage and Overage days
Electronics - Computers	48.01%	0.7933	- 0.0265	0.0408
Electronics - Consumer products	57.23%	0.2610	- 0.0185	0.0170
Electronics – PCB Assembly	73.24%	0.3135	- 0.0058	- 0.0084
Engineered – Aero (Co. A)	61.88%	0.8015	- 0.0055	0.0004
Engineered – Aero (Co. B)	98.16%	0.1400	- 0.0039	0.0190
Engineered - Automotive Tools	72.06%	0.1674	- 0.0619	- 0.0103
Engineered - Automotive Tools	98.55%	0.6183	- 0.0173	0.1314
Engineered - Pumps	61.89%	0.5227	- 0.0358	0.0463
Engineered - Pumps	52.25%	0.4070	- 0.0124	0.0161
Engineered - Pumps	90.61%	0.4190	- 0.0115	- 0.0173
Extrusions 01 Mar 1999	20.60%	0.7605	- 0.0301	- 0.0021
Extrusions 08 Mar 1999	10.10%	0.2471	- 0.0399	- 0.0005
Extrusions 16 Apr 1999	14.53%	0.5148	- 0.0308	- 0.0069
Extrusions 17 Mar 1999	10.15%	0.4307	- 0.0376	- 0.0066
Machinery	58.84%	0.7559	- 0.0008	- 0.0021
Moulding (1)	41.21%	0.2032	0.0443	- 0.0490
Moulding (2)	20.92%	0.7596	- 0.0301	- 0.0025
Vehicle Assembly	54.17%	0.1062	- 0.0761	0.5945
Vehicle Assembly	34.03%	0.1016	- 0.0172	0.0694
Vehicle Assembly	27.76%	0.1655	- 0.0317	0.0789
Vehicle Assembly	53.25%	0.6578	- 0.0264	- 0.0045
Vehicle Assembly - Raw Materials	70.27%	0.2594	- 0.0287	0.0660
Vehicle Assembly Finished Goods	65.57%	0.2618	- 0.0209	0.0585
Max	98.55%	0.8015	0.0443	0.5945
Min	10.10%	0.1016	- 0.0761	- 0.0490

Note Moulding (1) & (2) are the same business but before and after an overage reduction program. Extrusions are the same

We can approach the measurement of overage at two levels, at the item level and the aggregate level.

- If we considered the item's value we would, using the classical Pareto approach focus on high value. However we should perhaps also consider how quickly the item would be used up. This is known as the dissipation rate and is measured in days. For example, there could be a high value overage that will only take 3 days before it is within plan. Thus it is important at an item level to consider both the value and days of overage.
- At an aggregate level, the obvious choice is the percentage of the total inventory, which is the amount of inventory that is not planned (wasted asset). We could also refine the simple measure by understanding the percentage of all the items that are in overage, if it is a small number of parts then it will be easy to focus on and recover. Larger numbers of items will need to be prioritised to develop recovery actions. In the same way that it is useful to know how long an item will take before it is no longer in overage, it would also be useful to know the aggregated dissipation for a group of parts. This is shown in the dissipation curve Figure 4. It is the total time taken to dissipate the aggregate overage assuming no further non-compliance and no further fluctuation in demand. A steep curve means that the recovery will be quick, whilst a flat curve means a longer recovery time, which clearly carries greater risks of further changes that may lengthen recovery times.

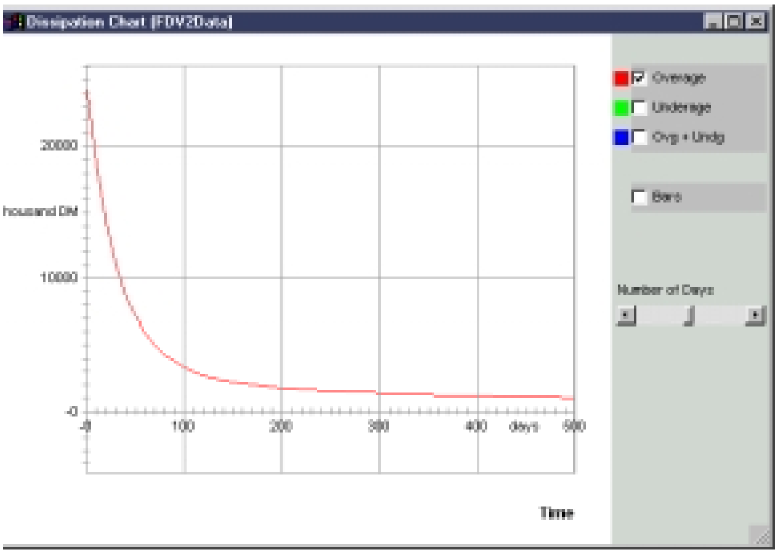

Figure 4 Inventory Dissipation Curve

How it might be planned

Overage Percentage

From our previous example, taking into account the overage will cause the enterprise to reduce safety and cycle stocks. However to implement overage planning and reduction actions we need to provide the planner with a valid algorithm that will allow him/her to project the likely level of overage in any future period. This algorithm would need to be linked to business performance in the same way that safety stock is linked to customer service / shortages so that a control feedback loop is established. One approach that could be used would be a percentage based on the past performance. This follows Hadley (1999), but whilst providing a straightforward approach it does not take into account any of the conditions that potentially influence the overage performance.

Safety Stock –The red herring

Overage can perhaps be thought of as the opposite of safety stock, since safety stock is planned to meet random demand variation, with overage being created as a result of random demand variation being lower than planned. In the same way safety stock based on safety lead-times protects against the supply being late, early arrivals will create overage. Thus, it may be possible to consider overage using the same assumptions in relation to the normal distributions that are used for the evaluation of safety stock as in Figure 5. This could be used to produce overage projections based on demand variation since this is seen as one of the causes of overage. However in inventory planning it is normally assumed that the business system would maintain the safety stock at its maximum level. In the same way for planning consistency we would have to assume that the business system would prevent overage from being created. The stable situation will always be the full amount of safety stock and no overage. If we consider the original argument for safety stock it is, in essence, to provide for the inability of the enterprise and system to react to a sudden change in demand. We should thus think of overage planning in the same way; the inability of the enterprise to react to the reduction in demand in the short term.

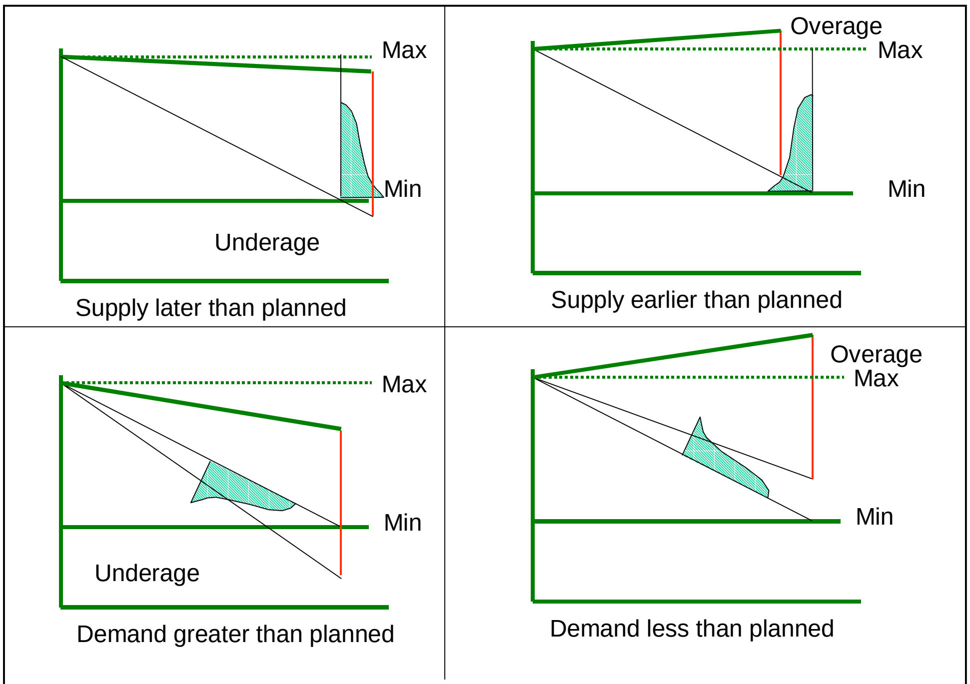

Figure 5 – Normally distributed supply and demand variations

Effect of the review cycle

However, if we consider the review and adjustment process used to put into changes effect, we see that either material has arrived before the review, or it is too late to make the adjustment and overage is already present. This overage will be accounted in the initial inventory value and the business system will attempt to adjust in a corrective action suggested by the system in the next review. If we use the example of our new product again (Figure 2 and 3) we can see how overage is created in a continuous review and adjustment process. In our previous discussion we identified possible causes, firstly, the corrective actions that are suggested and ignored and secondly, the corrective actions that are not suggested. Thus to predict overage we need to understand if we can predict the amount of overage created because of:

- Non-compliance to the corrective actions.
- The business system damping out the corrective action,
- The corrective action being inside a time fence and thus not suggested.

We also identified independent events as a potential source of overage. To predict them we should understand the frequency of occurrence and causes of these events. This will lead to a better understanding of the process failures.

We can clearly see that if the adjustments suggested by the business system are ignored then overage will be created. If we are to be able to plan overage we will need to know, based on experience, what the probable value of the adjustments are. If all the corrections were made then there should be no resultant overage, so we will also need to know the impact of the corrective actions not processed by the planners. If the business system uses damping and time fencing to prevent suggestions being made we will also need to know the full impact of suggested changes before any damping or time fence rules are applied.

There seems to be little value in an item level overage as is the case for safety stock as safety stock requires a positive action to ensure that materials are provisioned. Applying an overage allowance at item level would merely provide an excuse for inaction. The benefit of the inclusion of overage is at the aggregate level plan, thus pragmatically this is where the development of the algorithm will be focused.

We are thus looking to evaluate the steady state overage condition, which will mean making an assessment of how all the suggested adjustments to re-schedule out materials have been implemented. We can begin from the assumption that Overage equals the value of independent events creating overage plus the value of the probable reschedule-out and cancellations that are not processed by the Planner plus the value of the Probable Reschedule / Cancels that are not suggested for action due to dampening plus the value of the probable Reschedule / Cancels that are not suggested for action because they are inside the time fence.

Thus we can simply express overage in the form.

$$\text{Overage} = \sum_{i-1}^{n} O_{ie} + O_{in} + O_{id} + O_{if}$$

For Items 1 - n

Where :

O_{ie} = Items value of Overage caused by independent events

O_{in} = Items value of Overage caused by non-compliance

O_{id} = Items value of Overage caused by damping

O_{if} = Items value of Overage caused by time-fence

In order to evaluate and predict each of these elements we will need to measure the independent events, non-compliance and determine the damping and time-fence parameter settings that affect the suggestion process. It is important to realise that any proposed planning technique will only stand a chance of being taken up, if the addition effort required can be seen to add to the performance of operations and can be easily measured. If we consider the information that will be needed to evaluate overage, we can see that they are strongly related to effective control of the business. It is also reasonable to assume with modern systems that it is possible to capture the required data to enable the evaluation of non-compliance.
This implies;

- For business operations
  - Net positive stock adjustments between business system cycles
  - Inventory value of the business system suggestions before and after the application of damping and time fence parameters.
  - Adjustments made by planners to the business systems to re-schedule-out and cancellation suggestions.
- For business system settings
  - Time fences
  - Damping rules

On the basis that people will respond to that which is measured, ideal criteria would focus attention on good business practice. For example Ollie Wight's (1993) ABCD checklist identifies, time fences, damping rules and stock adjustments as key in the effective control of MRP systems.

Conclusions

From the above, we conclude that overage should not be dismissed as the result of poor planning-related to the uncertainty of demand and supply in the replenishment of cycle stock. Inventory planners have always used safety stock to protect customer service levels and thus the revenue and profitability of the business. The paper concludes that overage should be recognised in the same way as safety stock and planned, as its effective control will enhance the business's profitability by minimising the inventory investment.
The paper argues that overage is important because there is evidence that, even in well managed businesses a significant proportion of the inventory is in overage at any given time. An evaluation of twenty-inventory profiles show between 10% and 98% of the inventory values were was 'in overage'. For most businesses this will not be a trivial amount and any actions that can reduce it will bring significant benefit to the business.
Finally the paper concludes that from understanding the possible causes of overage, we can see that it is both possible and desirable to collect the relevant data to enable an evaluation of overage to be made during the business planning process.
Our future research will investigate various planning models that will allow inclusive planning of overage. The research will also investigate the nature of the causes of overage and how appropriate measurement and control may be applied.

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