Toward Controlling the *Planning* of Operations: An Accounting Scheme for *Planned* Inventory

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Provided here are a classification scheme for planned inventories and an accounting procedure for calculating classes of planned inventory assuming an ERP environment. The classification is based on the motives for holding inventory. The accounting procedure is useful as it facilitates controlling the quality of the production planning process. It gives direct decision support for understanding the inventory implications of safety stock, capacity planning, and economic batching and how such decisions are intertwined. The scheme accounts for all planned inventory into mutually exclusive categories. Modifications for embedding the scheme into the planning interface of an ERP-based planning system are illustrated.

INTRODUCTION

Consider the problem of a production planner operating in an ERP-based system within a manufacturing firm that purchases materials and components and processes them to produce finished products. The planner is responsible for planning the production for each stock keeping unit (SKU) that the firm produces. Production quantities and their timing must be within the capacity of the required facilities and must meet the associated requirements that descend from upper levels within the planning system. Aside from meeting such requirements the planner must assure that specified safety balances are included in the production plan. For such environments, a natural question to ask is, "What is the level of inventory that will result from the current plan and what is the justification for it?" This is the gist of this report – to provide a calculus for examining a production program and extracting from it a reckoning of the inventory that it will produce. If this can be done for each SKU then it is a simple matter to summarize over all SKUs and extend to unit cost information to determine the total inventory investment implied by an overall production program.

Current methods for classifying manufacturing firms' operating[1] inventory include the following classification schemes:

a) by nature of demand (Independent vs. Dependent) (Orlicky, 1975, p. 22),
b) by usage and value (e.g., A-B-C or Pareto analysis) (Anderson and Clancy, 1991, p. 214; Hadi-Vencheh, 2010), and
c) by process stage (Raw Material, WIP, Finished Goods). (Horngren and Sundem, 1993, p. 123).

These schemes help answer questions such as:

a) "*What type of planning system should we use*?"
b) "*Which inventory is more important to control*?" and
c) "*How close is the inventory to cash*?" respectively.

Classification schemes like item c) above, report existing inventory levels by category and provide an accounting of the current level (worth) of the firm's inventory assets. They do not provide information regarding the future level of assets, so are of little help in the evaluation of different plans for production and operations. This paper seeks to answer a different line of questioning also believed to be important, e.g., "*What inventory are we planning to have*?" and more importantly, "*Why are we planning to have it*?" The motivation here is to develop a scheme for the classification of planned inventory. Thus, the emphasis here is on the control of the planning process, i.e., to see if inventory planning is being done well. To this end, introduced here is a time-phased classification of planned inventory by motive and a corresponding accounting procedure for calculating it in a modern ERP-based system. A continuing theme in the literature of management accounting is how to assure that accounting information is in support of management decision-making (e.g., see Küpper, 2009). This report directly addresses this issue as it aims to provide useful accounting information for supporting decisions in production, inventory, and capacity planning and control.

The balance of this article is organized as follows. In the next section the relevant literature is reviewed. Section 3 presents the proposed inventory classification scheme. Section 4 provides a procedure for calculating inventory for each of the proposed categories of planned inventory. Section 5 presents a prototype planning interface that employs the proposed scheme as it might be used in an ERP-based planning system. Section 6 concludes with some final remarks.

INVENTORY MOTIVES: RELEVANT LITERATURE

The scheme proposed here is inspired by the works of Arrow, Karlin, and Scarf (1958), Pfohl (1990), Vollmann, Berry, and Whybark (2002), Narasimhan, McLeavey, Billington (1995), Nahmias (2001), Sürie and Wagner (2002), Fleischmann (2003), and Neale, Tomlin, and Willems (2003).

Probably one of the first works to consider classifying existing inventory by motive is found in Arrow, et al. (1958, p.4) who describe three motives: *transaction, precaution, and speculation*. Why inventory is held is also the starting point of the inventory classification by Narasimhan, McLeavey, Billington (1995, p. 91-93). They distinguish:

a) Transaction Stocks: work-in-progress stocks and pipeline inventories (i.e., transportation inventories, inventory in transit)
b) Organization Stocks: safety stock, anticipation inventory/leveling inventory, lot size inventory/cycle inventory, scheduling stocks, speculative stocks
c) Excess Stocks: inventory with no purpose

Pfohl (1990) provides a classification of "Lagerbestände" (German for "stocks"). Lagerbestand is physical stock between production and/or transfer processes, i.e., operating inventory as used above. Like the aforementioned authors, Pfohl's classification scheme is to itemize the functions of stocks; i.e., according to why they are held. His functions or reasons for holding stocks include:

1. To take advantage of economies of scale
2. To smooth the discrepancies between capacity and demand
3. To speculate in light of potential shortages or higher prices
4. To protect against uncertainty in demand and/or supply

Pfohl identifies a number of additional functions including sorting, flexibility, substitution, and lead-time-reducing. Sorting occurs when the order in which jobs are being processed is rearranged. An example is the sorting of parts before and after a paint facility. Parts with the same color requirement are collected in front of the facility, painted, and thereafter resorted in their original flow order. This can be considered as part of the production process specification (the manufacturing technology) and thus not a "motive."

Pfohl's flexibility, substitution, and lead-time-reducing functions are related to the goal of maintaining high customer service. The tactic of holding inventory of semi-finished goods, awaiting final processing until receipt of specific customer orders, would exemplify these functions. This delay tactic has more recently been described as "postponement". (See for example, Simchi-Levi, Simchi-Levi, and Watson, 2003). Flexibility is achieved because this inventory can be used to support different finished goods requirements; the substitution function occurs because semi-finished goods are held instead of more expensive finished ones; the lead-time-reducing function is achieved because lead time is reduced to the time needed to perform final operations only. One could say that the flexibility, substitution, and lead-time-reducing functions each arise out of the uncertainty of demand (or supply). Thus in that sense, the inventory falls under the category of safety inventory, which is described in the section to follow.

Similarly, Nahmias (2001, p. 195-196) explains the following factors as a motivation for holding inventory: economies of scale, uncertainties (w.r.t. external demand, lead time, or supply), speculation, transportation, smoothing, and logistics constraints (e.g. minimum shipping quantities).

Whereas all of the aforementioned authors describe the possible different motives for holding inventory, none has sought to develop methods for measuring inventory according to their classification. Developing a scheme for classifying planned inventory by motive and a procedure for measuring it according to the classification scheme is the goal here. Specifically, provided here is a consolidation of these ideas with the goal to provide an accounting method that enables examining a firm's planned inventory and classifying it according to "motive" – and affording the subsequent use of this information to support decision making in the planning of operations. Thus, planned inventory is classified according to *why* it will occur. As described by Neale, Tomlin, and Willems (2003, p.37), classifying planned inventories in this way enables managers to better address inventory planning questions of location, level, and timing. Moreover, as illustrated in the prototype to be described below, such a schema can serve as the foundation in support of simultaneous integrated decision-making for capacity/capital, production, material/inventory, and cash flow planning. Integration and coordination are key principal goals of controlling. In this case, those efforts are directed at controlling the production and operations planning process.

A CLASSIFICATION SCHEME FOR PLANNED INVENTORY

One can refine the motive-based classification schemes of the aforementioned authors to classify planned inventory over a planning horizon comprised of n periods, into the following mutually exclusive, collectively exhaustive categories. At the end of any planning period t (t = 1,…, n) we have:

1. SI(t) – ***safety*** and/or hedging inventory due to precaution against risk and/or uncertainty of demand, and/or production rate, and/or transport time[2]
2. CI(t) – **capacity** smoothing inventory due to the timing mismatch between limited capacity (of transport and/or process) and demand
3. BI(t) – **batching** inventory due to economies of scale in production/transport

Note that the above scheme is essentially that as proposed by Pfohl, but with safety from uncertainty and speculation/hedging combined. This is done here to simplify exposition; the classification and method for accounting can be easily extended to this more general case.[3] Note also that inventories categorized by others as transit, lead time, or pipeline inventories are included here under the rubric capacity inventory. For example, the maximum processing rate for an SKU is its capacity which determines its lead time. When requirements exceed capacity we must build early thus causing CI. Other common categories such as excess and obsolete inventory are not included because we assume they would never be deliberately planned. Thus, all possible motives for planned inventory can be consolidated into the three categories, SI, CI, and BI. The remaining issue is to assure that this classification forms a partition so that total planned inventory at the end of planning period t, TI(t), is

$$TI(t) = SI(t)+CI(t)+BI(t).$$

How to form such a partition is provided below after a more detailed description of each of the three classes.

Safety Inventory, SI

Desired safety balances (DSB) are planned because of uncertainty in supply and/or demand. The typical thought process is to assume some desired level of customer service (either in terms of stockout probability or fill rate); then, given the probability distribution of demand and lead time, to compute the desired safety balance. Such derivations are not the subject here; we assume that desired safety balances have already been established. See Hopp and Spearman (2001), for example, for a good review of DSB calculations.

An important distinction is made here between DSB and safety inventory (SI). The desired safety balance in period t, DSB(t), is the planner-specified minimum inventory that is planned for the end of period t. SI(t) is the inventory that will occur in period t as a result of this planning process. To see this, consider the following 3-period example for one SKU of a fictive firm as shown in Table 1. For ease of illustration, beginning inventory is assumed zero. The planner sets planned production (PP) to satisfy gross requirements (GR) and desired safety balances (DSB) with minimum inventory. As indicated in the table, the resulting end-of-period total inventory is TI(t) = TI(t-1)+PP(t)-GR(t), which is completely attributable to the desired safety balances.

TABLE 1
ILLUSTRATION OF SAFETY INVENTORY, SI, ARISING FROM DESIRED SAFETY BALANCES

Period:	1	2	3	Total
Gross Requirements (GR):	100	15	80	195
Desired Safety Balance (DSB):	20		10	30
Planned Production (PP):	120		85	205
Total Inventory (TI):	20	5	10	35
Safety Inventory (SI):	20	5	10	35

Table 1 illustrates the special character of SI. A reduction in DSB instigates a reduction in SI; but SI can only be reduced to the extent allowed by gross requirements. As shown in the table, DSB drops from 20 in period 1 to 0 in period 2. Because gross requirements in period 2 are only 15 units, SI can only be reduced to 5 units. In period 3 planned production of 85 satisfies the 90 units arising from gross requirements and the desired safety balance.

Capacity Smoothing Inventory, CI

The rendition here of capacity smoothing inventory is a generalization of Hopp and Spearman's "critical WIP" – i.e., it is the WIP level achieved when a resource with given capacity to produce achieves minimum average flowtime (see Hopp and Spearman, 2001, p. 219). The difference is that Hopp and Spearman assume constant capacity; assumed here is any discrete time profile of capacity. As intended here, capacity smoothing inventory is the minimum inventory needed to satisfy gross requirements and the desired safety balances throughout the planning horizon. When for some period t, GR(t) exceeds the available capacity, then in one or more periods, t-i, in which there is adequate capacity, there is a need (a requirement) to build ahead. Such build ahead requirements are referred to here as capacity adjusted requirements, CAR(t-i). Such planning is sometimes referred to as "production smoothing." This characterization is misleading. Planned inventory in this case exists because the time profile of capacity is limited and differs from the time profile of demand. Normally, the example is seasonal demand and constant capacity. But consider the case of constant demand and time varying capacity. Then we need to have inventory to accomplish "unsmooth" production! Time-varying capacity happens, for example, as a result of previous commitments of a resource as well as shift and vacation schedules, etc. Interestingly, in the case of time-varying capacity, the planning of inventory to smooth the discrepancy between capacity and demand could lead to the well-known "bullwhip" effect in which the variance of planned production (output) is greater than the variance of demand (input). On the other hand, in the case of seasonal demand and constant capacity we have high input variance and low output variance resulting in "production smoothing," the opposite of bullwhip (for details on bullwhip see Lee, Padmanabhan, and Whang, 1997, and Gorman and Kanet, 2011). The important point here is that such inventory is knowingly planned for the purpose of solving the mismatch between demand and capacity. Whether it leads to "smoothing" or "bullwhip" is not relevant here. The end result is a set of time-phased inventories, CI(t), t = 1,…, n. Table 2 illustrates how CI is generated when capacity is limited.

TABLE 2
ILLUSTRATION OF HOW LIMITED CAPACITY GIVES RISE TO CAPACITY ADJUSTED REQUIREMENTS AND CAPACITY SMOOTHING INVENTORY, CI

Period:	1	2	3	Total
Gross Requirements (GR):	100	15	80	195
Desired Safety Balance (DSB):	20		10	30
Capacity (C):	130	120	60	
Capacity Adjusted Requirements (CAR):	120	25	60	205
Planned Production (PP):	120	25	60	205
Total Inventory (TI):	20	30	10	60
Safety Inventory (SI):	20	5	10	35
Capacity Smoothing Inventory (CI):		25		25

Found in Table 2 are the same set of gross requirements and desired safety balances as the earlier example with the additional feature of limited capacity, C. Planned production is again set to satisfy gross requirements and desired safety balances with minimum inventory, but within production capacity. Resulting end-of-period total inventory, TI(t) = TI(t-1)+PP(t)-GR(t) is now the sum of SI and CI.

Batching Inventory, BI

Batching inventory is the inventory due to economies of scale in the production and/or transport processes. Economic lot sizing, purchase quantity discounting, consolidating of freight, etc., all give rise to batching inventory, BI(t), t = 1,…, n. Table 3 continues the earlier example by showing the resulting plan when the production in periods 2 and 3 are combined for economic reasons (e.g., to save a setup). Again, resulting end-of-period total inventory is TI(t) = TI(t-1)+PP(t)-GR(t) and is the sum of SI, CI, and BI.

TABLE 3
ILLUSTRATION OF HOW ECONOMIC BATCHING YIELDS BATCHING INVENTORY, BI

Period:	1	2	3	Total
Gross Requirements (GR):	100	15	80	195
Desired Safety Balance (DSB):	20		10	30
Capacity (C):	130	120	60	
Capacity Adjusted Requirements (CAR):	120	25	60	205
Planned Production (PP):	120	85		205
Total Inventory (TI):	20	90	10	120
Safety Inventory (SI):	20	5	10	35
Capacity Smoothing Inventory (CI):		25		25
Batching Inventory (BI):		60		60

COMPUTING SI, CI AND BI

The aforementioned inventory classes can be easily computed in a typical ERP-based production planning system. For a planning horizon {0, 1,…, n} assume that for each SKU that we are given a set of customer gross requirements (demands), GR(t), a set of desired end of period safety inventory balances, DSB(t), and a set of production capacities, C(t). Without loss of generality assume SI(0), CI(0), BI(0) = 0. The procedures explained below assign inventory to these classes in a hierarchical fashion: first to safety inventory, followed by capacity inventory, and finally batching inventory.

Determining SI

Determining SI is somewhat complicated by the fact that desired safety inventory balances are never planned to be used and may change over time. The concept of "virtual requirements", as done in SAP's advanced planning module, APO, can be adapted to compute SI (see Hoppe, 2007 for details). In doing this, two types of virtual requirements, positive requirement adjustments, PRA(t), and negative requirement adjustments, NRA(t), are employed. Each virtual PRA artificially inflates demand. Thus, each PRA has to be offset in a later period by one or more NRAs. NRAs may have to be distributed over a number of future periods because a period's total requirements cannot be allowed to fall below zero. To save inventory, NRAs must occur as early as possible. The following simple linear program assures all this. The procedure provides safety stock adjusted requirements, SSAR(t). In other words, SSAR are the original gross requirements, GR, adjusted for the desired safety stock balances, DSB. For a planning horizon comprised of n periods, define the following input parameters:

$GR(t) \geq 0$: gross requirements (demand) for period t ($t = 1,\ldots, n$),
$DSB(t) \geq 0$: desired safety stock inventory balance as of end of period t ($t = 1,\ldots, n$),

and the following decision variables:

PRA(t): positive requirement adjustments for period t ($t = 1,\ldots, n$),
NRA(t): negative requirement adjustments for period t ($t = 1,\ldots, n$),
SSAR(t): safety stock adjusted requirements for period t ($t = 1,\ldots, n$),
SI(t): safety stock induced inventory at end of period t ($t = 1,\ldots, n$).

The linear programming formulation is then as follows.

Minimize: $\Sigma_{t = 1,\ldots, n} SI(t)$

Subject to:

$NRA(t) \leq GR(t)$ $(t = 1,\ldots,n)$ (1)
$SSAR(t) = GR(t)+PRA(t)-NRA(t)$ $(t = 1,\ldots, n)$ (2)
$SI(1) = PRA(1)-NRA(1)$ (3)
$SI(t) = SI(t-1)+PRA(t)-NRA(t)$ $(t = 2,\ldots, n)$ (4)
$SI(t) \geq DSB(t)$ $(t = 1,\ldots, n)$ (5)
$PRA(t), NRA(t), SSAR(t), SI(t) \geq 0$ $(t = 1,\ldots, n)$ (6)

As indicated, the objective is to minimize total SI through the planning horizon. Constraints (1) assure that negative requirement adjustments do not exceed gross requirements. Constraints (2) sets safety stock adjusted requirements to gross requirements with all adjustments. Constraints (3) and (4) assure balanced inventory. Constraints (5) assure that safety inventory always meets desired inventory balances. Constraints (6) assure non-negativity. Table 4 provides the LP solution to the sample situation described earlier. Note that projected safety inventory and SSAR are independent of capacity and planned production.

TABLE 4
EXAMPLE LP SOLUTION FOR SAFETY INVENTORY

Period:	1	2	3	Total
Gross Requirements (GR):	100	15	80	195
Desired Safety Balance (DSB):	20		10	30
Positive Requirement Adjustments (PRA):	20		10	30
Negative Requirement Adjustments (NRA):		15	5	20
Safety Stock Adjusted Requirements (SSAR):	120		85	205
Safety Inventory (SI):	20	5	10	35

Determining CI

Given SSAR and a set of capacities C, we can compute CI and CAR by means of the following simple linear program. We assume that for each period t in the horizon that
$\Sigma C(j) \geq \Sigma SSAR(j)$ for $j = 1,\ldots, t$, i.e., there are no capacity shortages.[4]

Minimize: $\Sigma_{t = 1,\ldots, n} CI(t)$

Subject to:

$CAR(t) \leq C(t)$ $(t = 1,\ldots, n)$ (1)
$CI(1) = CAR(1)-SSAR(1)$ (2)
$CI(t) = CI(t-1)+CAR(t)-SSAR(t)$ $(t = 2,\ldots, n)$ (3)
$\Sigma_{j = 1,\ldots, t} CAR(j) \geq \Sigma_{j = 1,\ldots, t} SSAR(j)$ $(t = 1,\ldots, n)$ (4)
$CAR(t), CI(t) \geq 0$ $(t = 1,\ldots, n)$ (5)

Constraints (1) assure that capacity adjusted requirements are within pre-specified capacities. Constraints (2) and (3) assure inventory balance. Constraints (4) assure that all SSAR are met. Table 5 provides the solution values for CI and CAR for the example situation described above.

TABLE 5
EXAMPLE LP SOLUTION FOR CAPACITY SMOOTHING INVENTORY

Period:	1	2	3	Total
Safety Stock Adjusted Requirements (SSAR):	120		85	205
Safety Inventory (SI):	20	5	10	35
Capacity (C):	130	120	60	
Capacity Adjusted Requirements (CAR):	120	25	60	205
Capacity Smoothing Inventory (CI):		25		25

Thus, CI represents the projected available inventory balances caused by the discrepancy between safety stock adjusted customer requirements and capacity adjusted requirements. CI can be considered as an investment to avoid adding capacity.

Determining BI

Now that SI and CI have been identified, any additional inventory, BI, will be the result of the economics of batching of planned production PP. BI can be computed as follows:

$$BI(t) = BI(t-1)+PP(t)-CAR(t) \text{ for } t = 1,\ldots, n$$

or from

$$BI(t) = TI(t)-SI(t)-CI(t) \text{ for } t = 1,\ldots, n.$$

It is important to see that we do not need to know planned production to compute SI or CI. To compute CAR and CI, SSAR and SI must first be computed. BI occurs when PP exceeds CAR.

DEMONSTRATION INTERFACE TO ERP

Note that when the idea of inserting safety requirements is added to the planning task, then a procedure for updating these requirements is necessary, whereby such requirements may need to be occasionally rescheduled (i.e., increased, decreased, or re-timed). Moreover, as mentioned above, it may be desirable to plan different levels of safety requirements over time. (For more details regarding dynamic planned safety stock requirements see Kanet, Gorman, and Stößlein, 2010).

Presented in Figure 1 is a prototype planning system interface which demonstrates how safety inventory, capacity inventory, and batching inventory can be isolated and accounted for in a production plan. We anticipate this to be the interface for a production planner operating in an ERP environment. For simplicity of illustration and without loss of generality, assume beginning inventory level is zero. Given capacities and gross requirements, the planner's task is to insert desired safety stock levels and planned production (shaded cells). Note the entries for the three different classes of inventory and how they are time-phased over the planning horizon.

FIGURE 1
ILLUSTRATION OF PLANNING INTERFACE
EMPLOYING THE REPORTING OF INVENTORY BY MOTIVE

period:	1	2	3	4	5	6	7	8	9	10	11	12	Total
Gross Reqmts (GR):	60	10	20	100	10	180	390	10	10	240	15	20	1065
Desired Safety Balances (DSB):	15		10	20		20	30	5		30			130
SS Adj Reqmts (SSAR):	75		25	110		190	400			260		5	1065
SAFETY INV (SI):	15	5	10	20	10	20	30	20	10	30	15		185
Capacity (C):	230	110	200	270	100	90	330	60	100	30	60	60	1640
CAP SMOOTH. INV (CI):				140	240	140	70	130	230				950
CapAdjReqmts (CAR):	75		25	250	100	90	330	60	100	30		5	1065
Planned Prod (PP):	100			250	100	90	330	60	100	30		5	1065
BATCHING INV (BI):	25	25											50
TOTAL INV (SI+CI+BI):	40	30	10	160	250	160	100	150	240	30	15		1185

In this example we see that the safety stock plan causes average safety inventory of 185/12 = 15.4 units over the horizon. Observe how the capacity profile C differs from the profile of gross requirements and desired safety balances (Safety Stock Adjusted Requirements), giving rise to capacity smoothing inventory, CI, in periods 4-9, so that an average inventory due to the requirements-capacity mismatch of 950/12 = 79.2 units will occur. Moreover, note how the planner has decided to batch production (within capacity limits) in period 1, apparently to take advantage of reduced setup or quantity discounts, so that batching inventory occurs in periods 1 and 2. Total planned inventory is then summarized at the bottom of the table. It could subsequently be used as an input to cash planning.

We can easily envision how such a feature in an ERP system could be put to use in decision making. If we summarize over all SKUs that consume capacity from a particular resource, we can see how much inventory is being caused as a result of the current level of capacity utilization. We could use this information to perform a cash flow analysis of the benefits of adding capacity to the resource. Likewise, knowing the precise inventory implications could aid decision making in the setting of safety stock levels. Finally, the planner can readily see the inventory effects of his decision to batch production; it would be a simple matter to add holding cost information to the planning interface.

More sophisticated analyses are also facilitated by the breakdown of planned inventory as proposed here. For example, in the example interface shown above, it would be easy to show the planner when and how much capacity to add in order to reduce inventory or to make possible larger batches. Then the added economy of larger batches, the benefit of which would be the avoidance of cash outflows, could be compared to the cost of the added capacity (e. g. cash outflows due to overtime or equipment purchase). Figure 2 illustrates how support for capacity planning might be added to the interface.

FIGURE 2
PLANNING INTERFACE WITH CAPACITY MANAGEMENT

period:	1	2	3	4	5	6	7	8	9	10	11	12	Total
Gross Reqmts (GR):	60	10	20	100	10	180	390	10	10	240	15	20	1065
Desired Safety Balances (DSB):	15		10	20		20	30	5		30			130
SS AdjNet Reqmts (SSAR):	75		25	110		190	400			260		5	1065
SAFETY INV (SI):	15	5	10	20	10	20	30	20	10	30	15		185
Capacity (C):	230	110	200	270	100	190	400	60	100	265	60	60	2045
Capacity Additions:						100	70			235			405
CAP SMOOTH. INV (CI):													
CapAdjReqmts (CAR):	75		25	110		190	400			260		5	1065
Planned Prod (PP):	210					190	400			265			1065
BATCHING INV (BI):	135	135	110							5	5		390
TOTAL INV (SI+CI+BI):	150	140	120	20	10	20	30	20	10	35	20		575

Here we see that the interface now includes the capability for the planner to add capacity (as designated in the shaded row labeled "Capacity Additions"). Given the same customer requirements and desired safety levels as before, the planner now plans 100, 70, and 235 units of added capacity in periods 6, 7, and 10, respectively. This affords the additional batching of requirements (from 9 to 4 setups) as shown in the array of planned production. Capacity smoothing inventory is reduced from 950 to 0 units (total); batching inventory is increased from 50 to 390 units so that total inventory is reduced from 1185 to 575. Adding cost information would make a cash flow analysis now possible. One can see from this example how a decision regarding capacity is intertwined with an economic batching decision. It is the classification of planned inventory by motive that opens the door to this kind of integrated decision making in the planning of production.

For multi-level systems, additional bookkeeping is required. Once an SKU's production plan is determined, the planned production values explode to gross requirements for the SKU's required materials and the capacity profile(s) of the involved resource(s) is (are) updated to account for the capacity that the planned production consumes.

FINAL REMARKS

If a classification scheme is meant to guide or evaluate the production and operations planning process then it needs to have a number of important properties. Foremost is that the classification scheme should be well-defined and should form a partition of inventory – that is, it divides inventory into mutually exclusive, collectively exhaustive subsets. We have shown this to be the case here. SI is calculated independently of CI and BI; CI is calculated given SSAR and available capacities, C; and BI occur when planned production exceeds CAR. The scheme should be consistently and easily measureable and confirmable. It should be timely and clearly understandable to all parties; it should be relevant, i.e., its connection to the firm's strategic purpose is evident. It should be controllable (those involved have the wherewithall to do something about it) and all parties should find it agreeable and "buy-in" to it.[5] The prototype planning interface presented here clearly demonstrates these properties. It provides two new dimensions to the production planner's task. Not only is production planned but it is integrated with the management of desired safety balances and required capacity, all within the same interface. With the additional information provided in such a planning tool, managers can make informed decisions regarding how much inventory to have and exert a greater level of control over the production and operations planning process. The answer to the question, "*Why are we planning this much inventory?*", is readily apparent.

ENDNOTES

1. Here "operating inventory means materials that go directly into the firm's product to be eventually sold (In contrast with indirect materials or supplies used to support operations).
2. These requirements are inspired by a similar lists by Küpper (1994; 2005, pp. 245-247) for reporting accounting information and for designing incentive systems.
3. These requirements are inspired by a similar lists by Küpper (1994; 2005, pp. 245-247) for reporting accounting information and for designing incentive systems.
4. These requirements are inspired by a similar lists by Küpper (1994; 2005, pp. 245-247) for reporting accounting information and for designing incentive systems.
5. These requirements are inspired by a similar lists by Küpper (1994; 2005, pp. 245-247) for reporting accounting information and for designing incentive systems.

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