# Time-maths for Material Flow

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**Abstract**

The MRP basic calculation computes a future projection of the inventory level − on a time horizon at least equal to the total upstream lead-time − by algebraically summing the stock at hand, the planned receipts and the gross requirements coming from the Master Production Schedule (i.e. sales forecast and incoming orders, consolidated according to the proper lot-sizing criteria): if the projected inventory level of a certain item gets below the predefined safety stock level, a new procurement or production order is placed. While this basic calculation does work and is extensively used, it also appears to be over-engineered and − more important − to originate excess organizational costs, when compared to the simpler, more direct computation proposed and discussed here: it sums the sales at the present time to the difference between them and the sales occurred in the past − upstream lead-time far from now (whence the name "time-maths") − and then generates orders either directly (continuous replenishment), or aggregates succeeding computations either up to a predefined batch size or along a predefined period of time (variable batch size orders at fixed dates). Besides being − de visu − much simpler, the new computation provides also decisive improvements: lower organizational costs, by reducing and better focusing the forecasting efforts; further important cost reductions, by enabling to slash the operating stocks; much better service, by focusing the managerial attention on the optimization of the safety stock levels.

## Introduction

MRP enjoys outstanding success. Used practically everywhere, it enables to seamlessly plan and manage the material flow, across companies and along value chains.

This is true, however, only as long as one looks at material management from far enough. Indeed, some issues may be floated by looking more closely at the MRP inner workings:

- Over-engineering of the basic formula (stock-centered):

  *Order (t) = predefined batch size,*
  *IF / WHEN a predefined target stock level > [ stock (t) - sum expected sales (from t to t+LT-1) + sum incoming orders (from t-LT to t-1) ],*

  where *LT* is the upstream lead-time;

- Conditioned behavior of the safety stock levels in transient conditions: their reset to target level depends entirely on the sales forecast update (Exhibits 1a), otherwise the safety stocks are not reset and expose the company to a greater risk of stock-out (Exhibits 1b);

- Too wide scope and cost of the forecast update activities: inherently uncertain; intrinsically tied to the MRP traditional calculation; equally dedicated to large and small, fast and slow sales variations over time, without any specific focus.

The new computation proposed and discussed below provides important improvement opportunities and opens a different managerial scenario:

- The sales forecast is divided between small and large sales variations, and between fast and slow ones, thereby focusing the forecasting effort on large-AND-fast sales variations only, since small-OR-slow ones are automatically managed by the new computation;

- Placing of variable size orders at fixed dates is simplified (as opposed to the more frequent ordering of fixed batch sizes when needed); this, in turn, eases the synchronization of subsequent activities along the value chain, thereby allowing to slash the operating stocks, which soak up space and cash along the chain;

- Overall, the managerial attention is focused on the optimization of the safety stock levels, in their key service role of enabling a smooth response to sales variations.

## The new computation

The basic computation proposed here ("time-maths"), in its simplest form, reads as follows:

*Order (t) = sales (t) + [ sales (t ) - sales (t - LT) ],*

where *LT* is the upstream lead-time.

The first part of the formula merely replenishes what is sold; the second part resets the safety stock, which necessarily undergoes a temporary depletion (or boost) to sustain the sales variation until the upstream part of the value chain − after LT − can effectively respond (Exhibit 2).

The actual formula gets more complicated than the basic one, in a number of practical cases:

- With anticipated sales information, the part of the formula which resets the safety stock changes from

  ... *[ sales (t ) - sales (t - LT) ]*

  to

  ... *[ sales info (t ) - sales info (t - LT + Iadv) ]*,

  which progressively shrinks when the information advancement *Iadv* widens, to eventually vanish when it equals the lead-time (Exhibit 3);

- With multiple echelons, the second part of the formula, computed for each echelon, sums up to a sort of bull-whip effect, of which it represents the physiological, valuable component (Exhibit 4a, 4b);

- With combined multiple echelons and anticipated information, and even more with programmed sales orders (the s.c. "schedules", which include multiple values, with different time advancements), the formula just becomes a linear combination of multiple contributions.

The utilization of the new formula opens up interesting possibilities, although with some mathematical concerns to take care of in the area of lead-time:

- The new computation generates orders either directly, or succeeding computations are aggregated either up to a predefined batch size or along a predefined period of time (in order to place fixed-size batch orders or periodical, variable-size orders, respectively); in the latter case, however, the equivalent lead-time to be considered happens to be larger than the nominal one;

- The synchronization of subsequent activities along the value chain is enabled in two possible modes − partial (time phasing only), or full (quantity equalization too) − which both modify the equivalent lead-times to be considered (the indicated increase in lead time would impact just once, on the downstream echelon) and, in case of full synchronization, would eliminate also the bullwhip effect.

**Advantages of the proposed computation**

The new computation provides some clear advantages:

- The forecasting effort can be focused on large-AND-fast variations only, since small-OR-slow changes are automatically managed by the new formula; this enables to concentrate the analysis on "true" sales variations, in the quest of "understanding" the market, rather than continuously adjusting the sales forecast with mathematical methods;

- A physiological, valuable component of the well known bull-whip effect is highlighted and taken into account ...in the hope that favorable upstream statistics provide a valid counterbalance;

- Operating stocks are possibly slashed by the synchronization of subsequent activities along the value chain / the bullwhip effect is possibly eliminated too.

Most of all, the safety stocks get to the center of the stage and managers invest in optimizing their levels, for their key service role of responding to sales variations.

**Conclusions**

The MRP works. Why bother?
Just because a solid, practical solution exists, it doesn't mean it is also the best one.

One should always explore improvements, by stress-testing the inner mechanics of both the algorithms at hand and the emerging alternatives.

A new, much simpler computation shows the intrinsic limitations and organizational drawbacks of the traditional approach, providing managerial improvement opportunities and suggestions for further research.

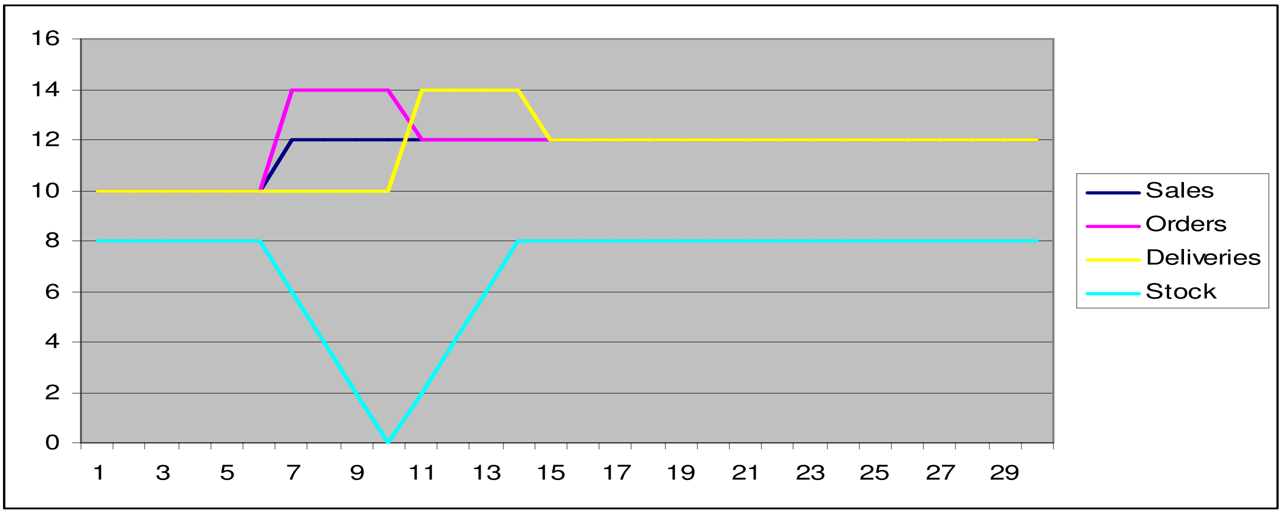


Exhibit 1a: Reset of safety stock **with** forecast update

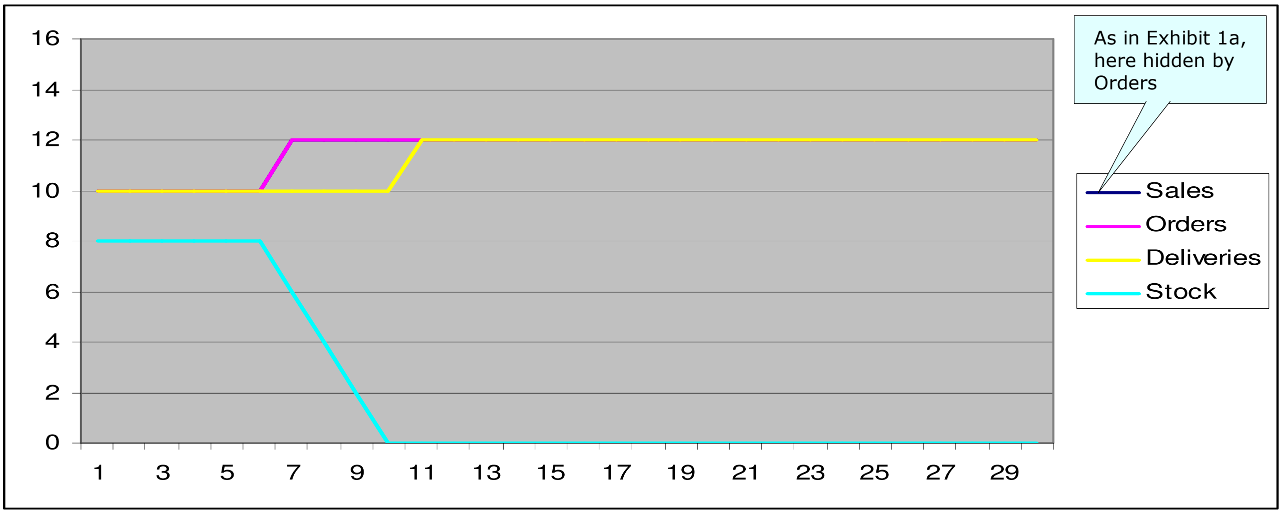


Exhibit 1b: No reset of safety stock / emerging risk of stock-out **without** forecast update

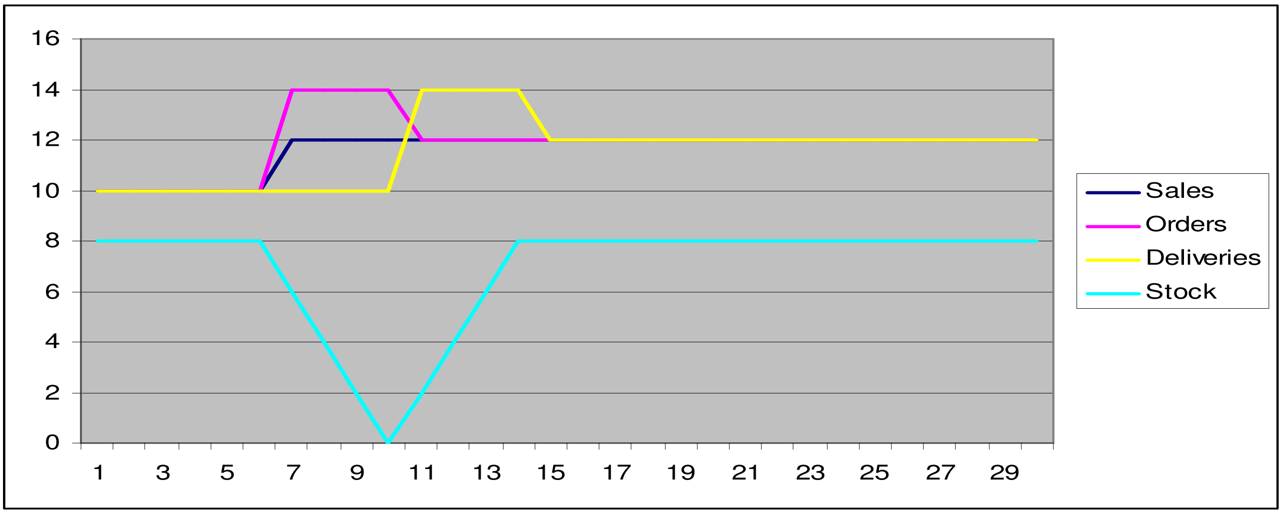


Exhibit 2: Basic "time-maths" formula, which automatically resets the safety stock

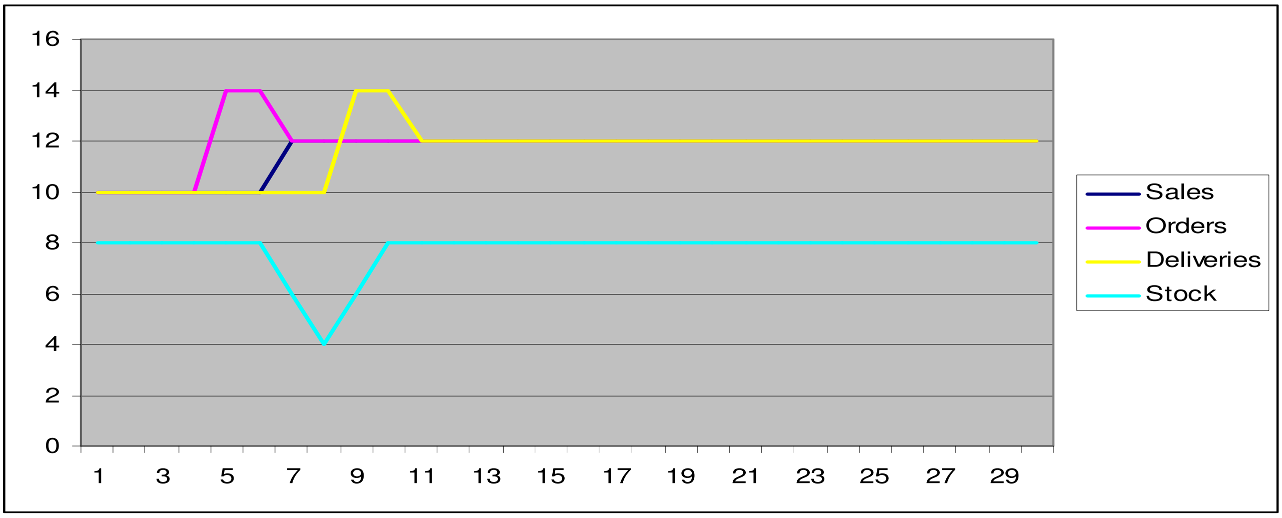


Exhibit 3: Basic "time-maths" formula, with anticipated sales information

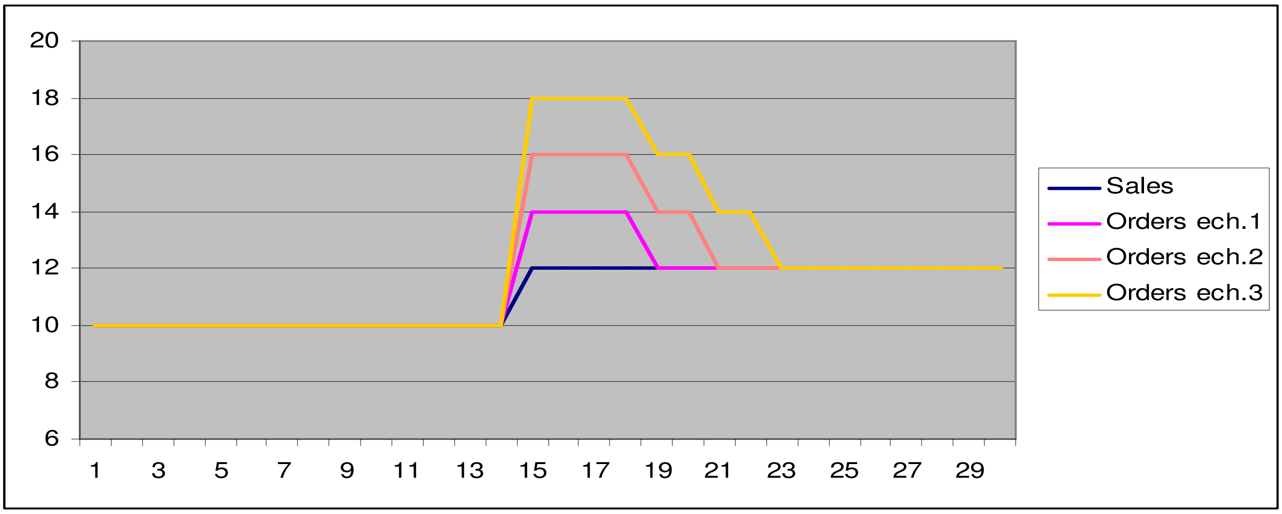


Exhibit 4a: Physiological bull-whip effect as a consequence of "time-maths" formula

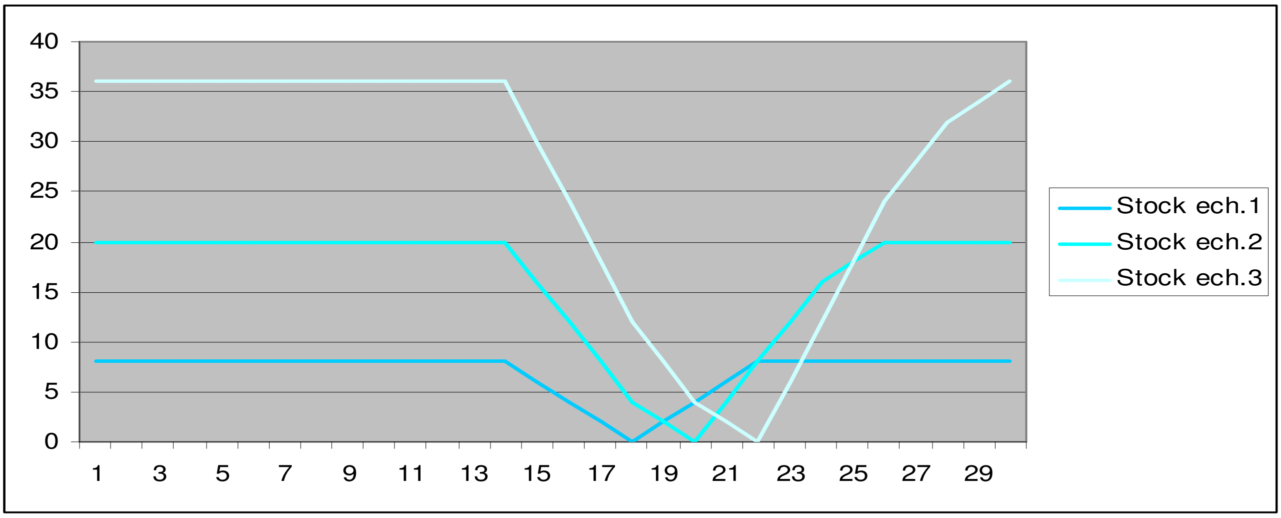


Exhibit 4b: Stock profiles with physiological bull-whip effect