

# CAMPAIGN PLANNING FOR MANUFACTURING SUPPLY CHAINS

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## ABSTRACT

In the process industry including pharmaceuticals, metals and chemicals, manufacturing supply chains are particularly long and complex. Moreover, the manufacturing operations are highly capacity intensive. In addition, companies must not only deal with the usual complexities of fluctuating demand from changing customer needs, competition, and economic pressures, but also with abrupt and unexpected changes that can upset carefully devised plans. In such an environment, Campaign Planning is pivotal for maintaining the efficiency of the manufacturing process. Consolidating the manufacturing demand by creating campaigns helps minimizing the total capacity setup time. Customer service and inventory levels need to be further taken into account while consolidating to achieve the desired supply chain management goals.

In this work, we present the complexity of Campaign Planning in Manufacturing and further discuss ways to improve it. We demonstrate why the new dynamic way of manufacturing demand consolidation is superior to the traditional fixed one. Finally, we present best practices through a case study with a pharmaceutical customer and related technologies. We conclude by outlining the need for proactive decision-making by employing a quantitative what-if-scenario analysis to further mitigate the supply chain's risk.

**KEYWORDS:** Campaign Planning, Supply Chain, Manufacturing, Consolidation, Supply Chain Management

## 1. INTRODUCTION

In a typical manufacturing environment manufacturing orders are issued to satisfy the customer demand orders. There can be manufacturing situations, where one big manufacturing order feeding multiple demand orders is preferred to many small manufacturing orders feeding those demand orders. Such consolidated manufacturing orders are usually preferred when orders need to be lot sized (quantity-based consolidation) into larger manufacturing orders for setup or process reasons, or grouped over a time period (time-based consolidation) to avoid multiple tiny runs of the same part number to control shop floor paperwork and reporting. In general, consolidation combines some of the manufacturing orders together into larger manufacturing orders. A given manufacturing order might directly feed several manufacturing orders, demand orders, or both. For example, if two manufacturing orders for 100 and 200 units of a specific part number start on Tuesday and Thursday, respectively, and the consolidation interval for the part number is one week, then a single manufacturing order of 300 units is created for this week to satisfy the two separate demand orders.

## 2. CAMPAIGN PLANNING

A certain type of manufacturing order consolidation is called Campaign Planning. In this process manufacturing orders are consolidated based on time or quantity parameters to form larger manufacturing orders which are called campaigns. Each campaign is uniquely defined by the following three characteristics:

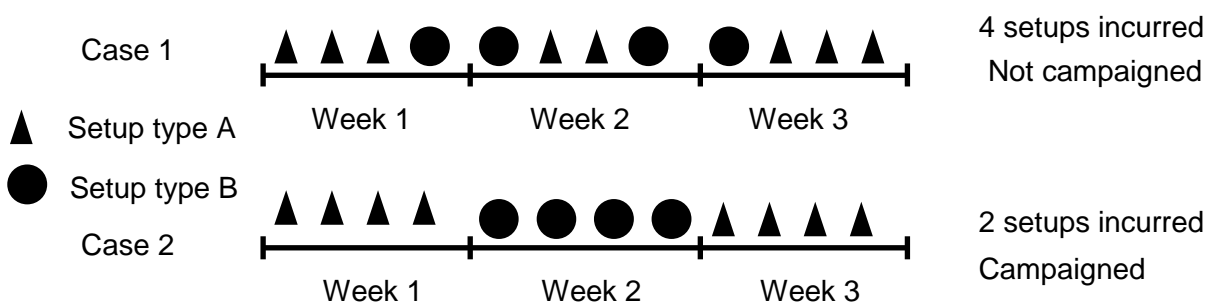
- Type: the part number or setup type the campaign represents
- Size: the total size of the campaign typically expressed in terms of time or quantity
- Sequence: the particular sequence of the campaign in a series of campaigns that need to be processed on a resource one after another. This is especially important for the setup time consideration when changing from one campaign (setup type) to another

The objective of Campaign Planning by forming those campaigns is to minimize the total setup time needed on a specific resource or alternatively to increase the efficiency of the resource utilization. This is especially crucial for asset intensive industries like chemicals, pharmaceuticals and metals. While forming the campaigns certain KPIs (Key Performance Indicators) are taken into account like:

- Customer Service Level: the percentage of customer demand orders fulfilled in full and on time
- Resource Utilization: the percentage of productive utilization of a resource
- Inventory Levels: the amount of inventory build-up in the manufacturing process

The Campaign Planning process is a constant trade-off between the above three KPIs. Moreover, having some stability in the customer demand picture is also crucial since demand fluctuations can alter significantly a well-devised campaign plan. Furthermore, lifetime expiration of a material can have a big impact on the formation of the campaigns since it limits the consolidation horizon. Finally, it is clear that Campaign Planning is a multi-dimensional problem.

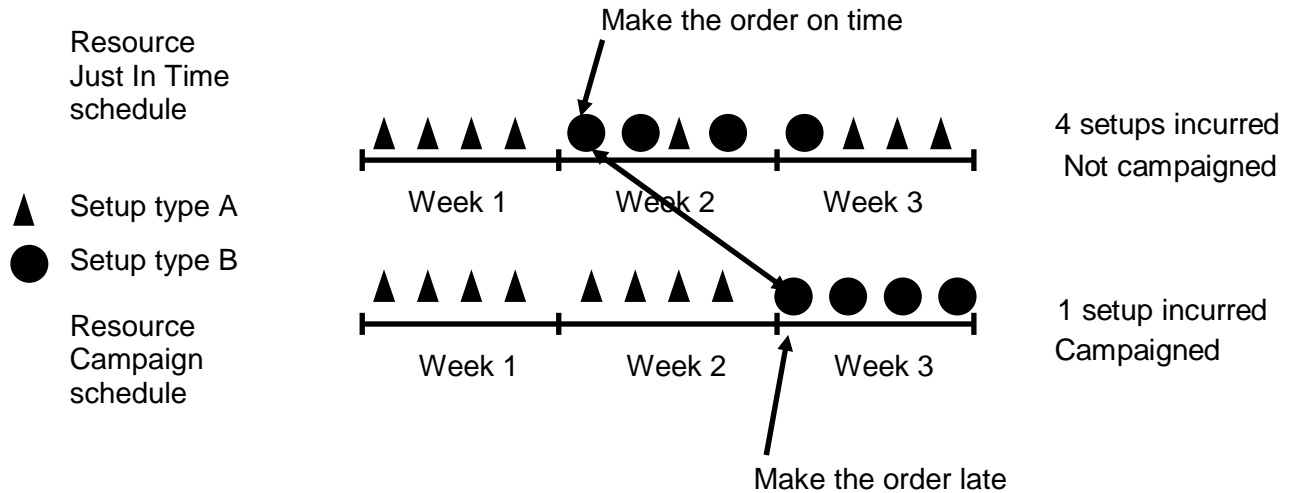
The following figure (Figure 1) depicts the trade-off between the multiple KPIs in Campaign Planning. There are two campaigns of two different setup types A and B. It is assumed that both cases 1 and 2 are feasible manufacturing plans. It is also assumed that both cases 1 and 2 satisfy the same customer service level i.e. both cases satisfy the orders in full and on time. It is further assumed that in both cases 1 and 2 the same setup time is incurred when changing from one campaign (setup type) to another.



**Figure 1:** Trade-off between KPIs with the same customer service level

Although both cases satisfy the same customer service level Case 2 is more efficient than Case 1 from a resource utilization perspective since it incurs only 2 changes compared to 4 changes from one type to another. The fewer changes of setup types the less time is required to setup the resource which in turn means increasing resource utilization. It is also obvious that both cases entail different inventory levels over time for types A and B which result into different inventory carrying cost.

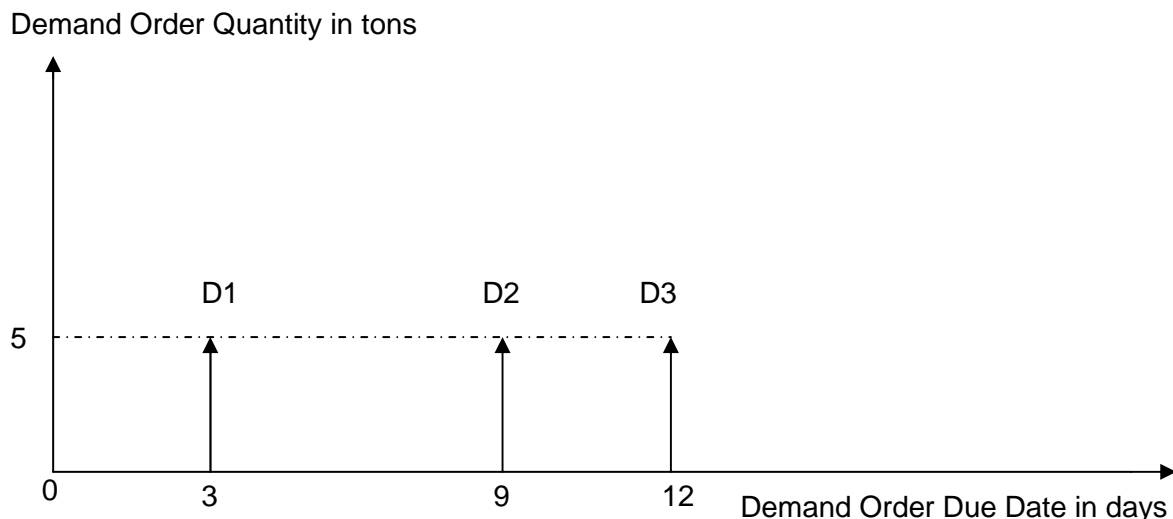
Campaign Planning can cause an order to be satisfied late. In the following figure (Figure 2) the Just in Time schedule shows a manufacturing schedule that is assumed to satisfy the orders in full and on time. While forming the campaigns, however, an order may be satisfied late for the sake of incurring fewer setups as it is shown in the Campaign schedule. That in turn increases the resource utilization. In both schedules the inventory levels over time and the resulting inventory carrying cost for types A and B are different.



**Figure 2:** Trade-off between KPIs with different customer service level

### 3. THE DYNAMIC CONSOLIDATION

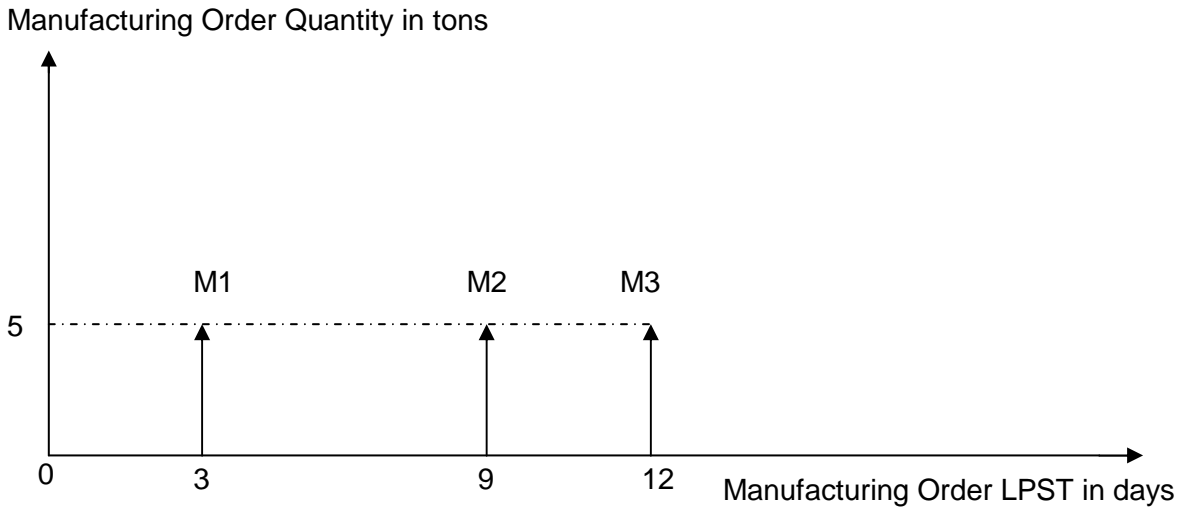
A very common type of Campaign Planning is the time-based consolidation. In this consolidation manufacturing orders are consolidated based on a consolidation interval that defines the horizon length of the consolidation. A starting point in the horizon for the reference of the consolidation intervals needs also to be defined. The consolidation intervals are contiguous and non-overlapping. The following figure (Figure 3) shows a few demand orders for a specific part number. Each demand order requires a certain quantity to be delivered to the customer at a certain date.



**Figure 3:** Demand Orders by part number

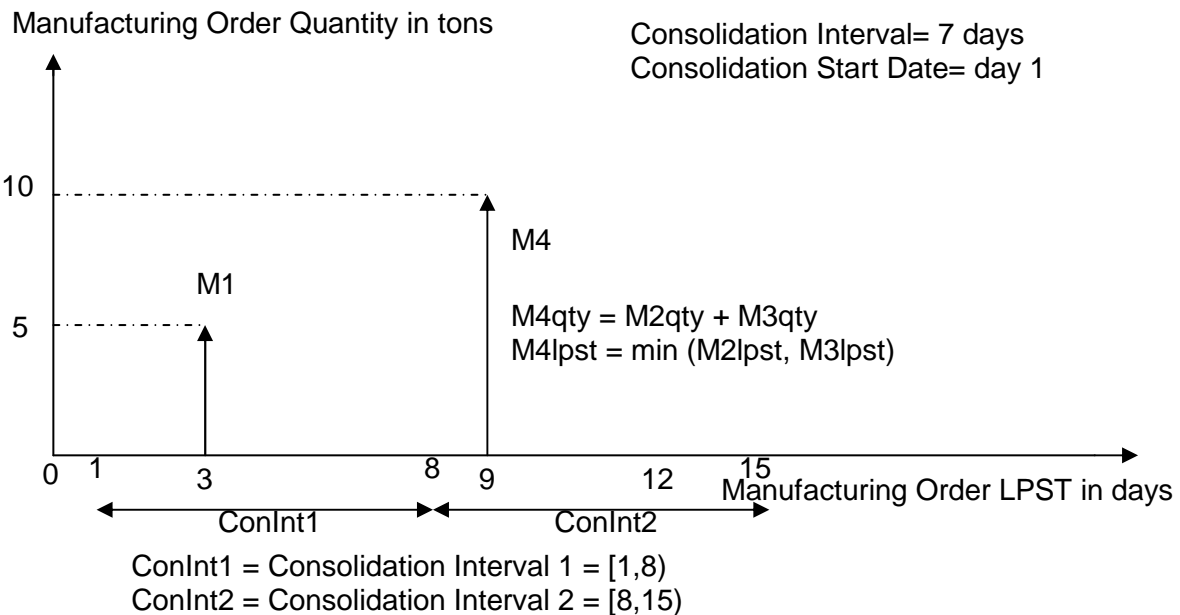
Manufacturing orders are issued to satisfy those demand orders by converting the requested demand order quantity into a manufacturing order quantity taking into account the demand

order due date and the lead time of the manufacturing operations. The following figure (Figure 4) shows those manufacturing orders for the specific part number. The latest possible start time (LPST) of a manufacturing order is the latest date to start the manufacturing order to make it on time. If the manufacturing order is started after that date then the order will be delayed.



**Figure 4:** Manufacturing Orders by part number

Traditionally the time-based consolidation is a fixed consolidation by part number as shown in the following figure (Figure 5). This consolidation is fixed because it has a fixed consolidation starting point in the horizon (day 1) and assumes non-overlapping and contiguous consolidation intervals. The length of the consolidation interval is 7 days in this example.

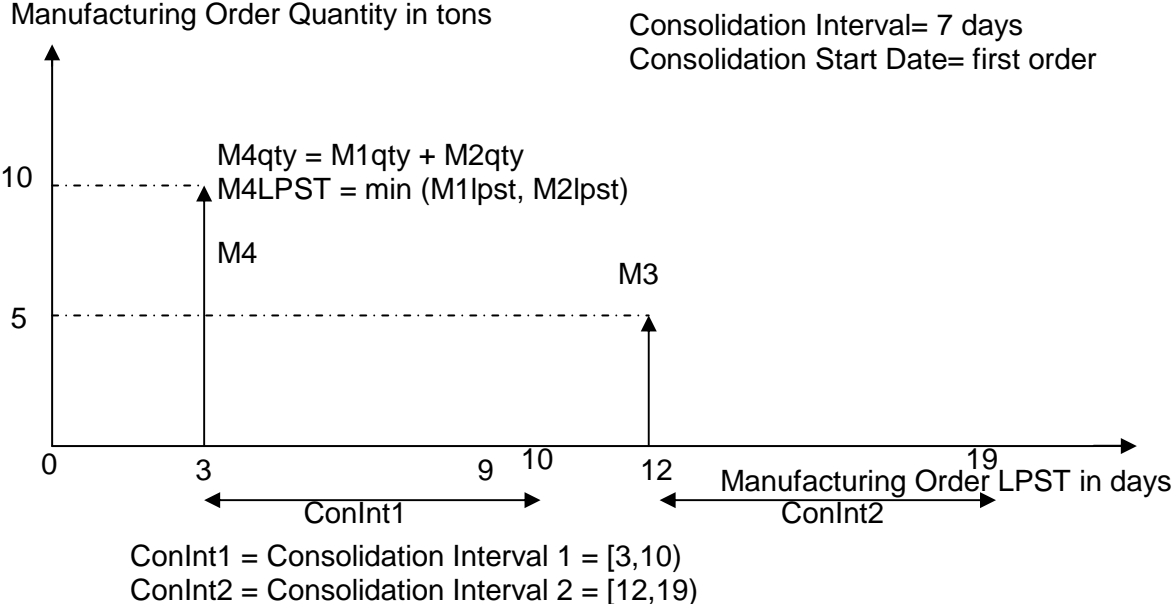


**Figure 5:** Fixed Consolidation by part number

The result of the fixed consolidation is the consolidation of the manufacturing orders M2 and M3 into a larger manufacturing order M4 with the following characteristics:

- The quantity of M4 is the sum of quantities of M2 and M3
- The LPST of M4 is the minimum of the LPSTs of M2 and M3

A weakness of the fixed consolidation is the assumption of consolidation in a contiguous interval manner after the first consolidation interval without considering the detailed demand and manufacturing order picture i.e. when is the next demand or manufacturing order after the first consolidation interval. This essentially can create more consolidated manufacturing orders than actually required. This weakness is eliminated by the so-called dynamic consolidation by part number as shown in the following figure (Figure 6) assuming the same initial demand and manufacturing order picture as before (Figures 3 and 4).



**Figure 6:** Dynamic Consolidation by part number

In the dynamic consolidation the consolidation starting point is the LPST of the first manufacturing order in the horizon. The consolidation interval remains the same for the sake of comparison but the consolidation intervals generated are different than in the fixed consolidation. The result of the dynamic consolidation is the consolidation of the manufacturing orders M1 and M2 into a larger manufacturing order M4 with the following characteristics:

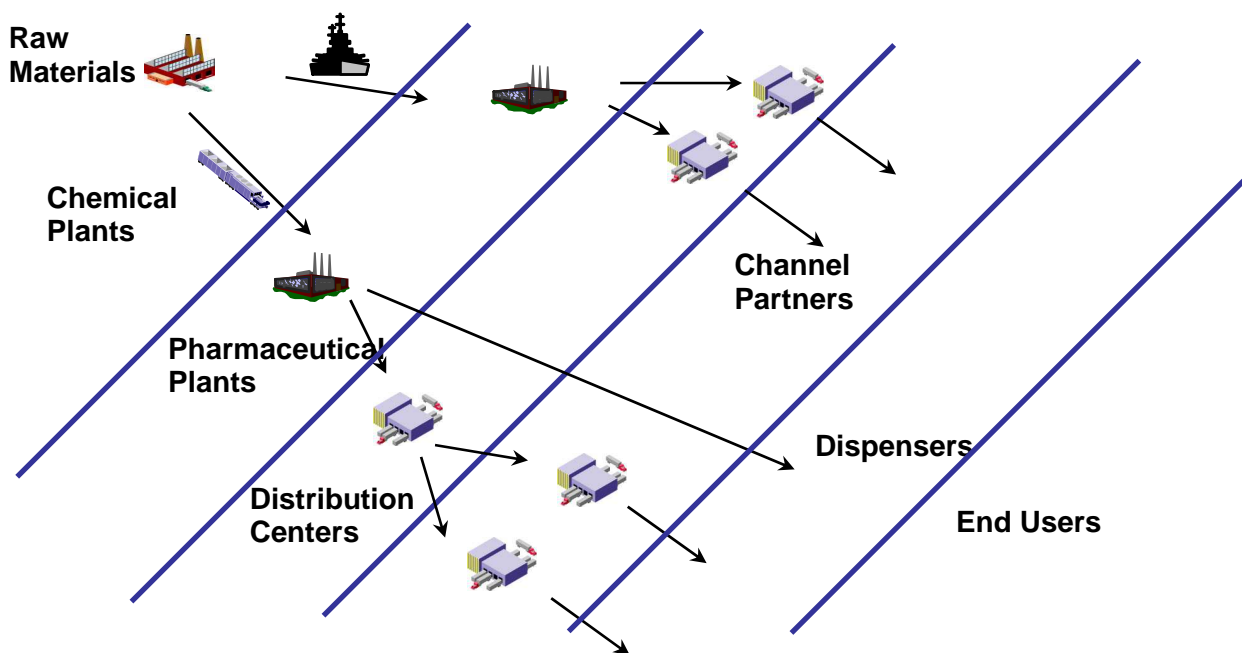
- The quantity of M4 is the sum of quantities of M1 and M2
- The LPST of M4 is the minimum of the LPSTs of M1 and M2

The strength of the dynamic consolidation is that it creates fewer consolidated manufacturing orders than the fixed consolidation within a specified horizon. For instance, in the comparison above for the first ten days in the horizon the dynamic consolidation created one consolidated manufacturing order M4 whereas the fixed consolidation created two consolidated manufacturing orders M1 and M4. It takes the detailed demand and manufacturing order picture into account and is more efficient. Finally, considering that each consolidated manufacturing order has a certain processing cost associated with it the financial implications and savings of the dynamic consolidation are obvious.

In most campaign planning relevant manufacturing environments the fixed consolidation is still widely used. It is typically implemented by older type of technology like Materials Requirements Planning (MRP) systems which are less dynamic. The dynamic consolidation requires more responsive technology and is better adjusted to the actual business needs. In conclusion, it realizes substantial manufacturing cost savings and contributes to a more agile manufacturing supply chain.

#### 4. A CASE STUDY

The case study refers to a top five pharmaceutical company. The pharmaceutical industry is an asset intensive industry. In such an environment, Campaign Planning is pivotal for maintaining the efficiency of the manufacturing process. That industry is highly regulated, fragmented and primarily a make-to-stock planning environment. Moreover, there is significant demand forecast volatility due to drug patent expirations. Supply chains are global, long and complex (multi-layered) with heterogeneous operations: chemical (long setups, up to two weeks long), formulation (moderate setups), packaging (short setups). Furthermore, there is limited available, usable capacity spread around the world with distinct, fixed and registered source patterns. Capacity operations are expensive to add and have long lead times (up to 4 years) from design to operation. The supply chain of that pharmaceutical company includes more than 30 chemical (chemical operations) and pharmaceutical (formulation and packaging operations) facilities and more than 8,000 SKUs (stock keeping units). The SKUs have a certain lifetime expiration which imposes an additional constraint in the manufacturing planning. The manufacturing asset base needs to be leveraged to produce maximum effectiveness and efficiency. The following figure (Figure 7) shows a typical pharmaceutical supply chain.



**Figure 7:** Pharmaceutical supply chain network

The manufacturing planning business process in place in that pharmaceutical company was facing the following challenges before the implementation of the new solution:

- Limited visibility into material and capacity requirements
- Long investment lead times required the anticipation of capacity needs
- Need for a consistent way to measure capacity and requirements (multiple business processes and disparate models)
- Need for a consistent manner to quickly evaluate what the effect of decisions might be if made
- Need for a global coordinated consistent method to plan and value long term inventory and production
- Decreased asset, labor and resource utilization
- High inventory levels

- Long manufacturing cycle times
- Long planning cycles
- Decreased responsiveness

With the implementation of the new solution in which the Campaign Planning function (Dynamic Consolidation) is key to the new manufacturing planning business process the pharmaceutical company experienced the following:

- Significantly improved global visibility of the supply chain
- Increased quality of capacity related decision making through a single consistent approach to modeling and capacity evaluation (single model)
- Reduced cycle time in capacity evaluation through well-designed information gathering and advanced simulation algorithms for modeling
- Formal business processes are enabled
- Consistently good customer service
- Increased efficiency and asset utilization
- Reduced inventory levels
- Reduced manufacturing cycle time
- Reduced planning cycle time (strategic planning cycle time is reduced from weeks to hours and resource scheduling cycle time from 3 to 5 days to a few hours)
- Increased responsiveness

The solution is implemented in three distinct planning levels (point solutions) : strategic, tactical, operational/resource scheduling. Each point solution is supported by the capability of concurrent evaluation of multiple what-if-scenarios.

### *Strategic Planning*

Scope:

- With respect to time: Year 2 through Year 10
- With respect to assets: those assets which are either expensive to acquire, have a long lead time to acquire or are specialized or complex in nature
- With respect to operations: Chemical and Pharmaceutical Manufacturing, Pharmaceutical Packaging

Needs:

- Long investment lead times require the anticipation of capacity needs
- Need for a consistent way to measure capacity and requirements
- Need for a consistent manner to quickly evaluate what the effect of decisions might be if made
- Need a consistent method to plan and value long term inventory and production

Solution Components:

- Campaign Planning (Dynamic Consolidation) is the key planning component
- Superior visibility of all supply chain information
- Simulation of planning goals similar to those which facilities undertake in their own planning
- Minimization of the total setup time on resources

- Intelligent use of alternate sources of supply
- Intelligent use of alternate capacity

Integration:

- Long range demand planning systems
- Supply information systems
- Financial systems

Value:

- Global visibility of the supply chain
- Increased quality of capacity related decision making through a consistent approach to modeling and a systemic capacity evaluation
- Reduced cycle time in capacity evaluation through well architected information gathering and advanced simulation algorithms for modeling
- Formal business processes are enabled

### *Tactical Planning*

Scope:

- With respect to time: Month 2 to Month 24
- With respect to assets: same as with strategic planning but usually only formulation and packaging
- With respect to resources: manning
- With respect to operations: Chemical and Pharmaceutical Manufacturing, Pharmaceutical Packaging

Needs:

- Inventory planning
- Master planning
- Global coordinated planning
- Raw material procurement/vendor scheduling

Solution Components:

- Campaign Planning (Dynamic Consolidation) is the key planning component
- Optimal determination of location and quantity of inventory
- Demand variability consideration on inventory levels
- Tradeoff analysis between service levels and inventory levels

Integration:

- MRP systems
- Financial systems
- Order management systems
- Operational planning systems

Value:

- Global visibility of the supply chain
- Consistently good customer service



- Increased efficiency (resource utilization)
- Reduced manufacturing cycle time
- Reduced inventory levels
- Reduced planning cycle time
- Increased responsiveness

#### *Operational Planning/Resource Scheduling*

##### Scope:

- With respect to time: Month 0 to Month 2
- With respect to assets: chemical, formulation and packaging assets
- With respect to resources: manning, tooling, raw materials, packaging components
- With respect to operations: Chemical and Pharmaceutical Manufacturing, Pharmaceutical Packaging

##### Needs:

- Efficient resource scheduling
- Consistent with tactical planning
- Need for shelf life consideration
- Need for quality control coordination
- Need for lot-tracing

##### Solution Components:

- Campaign Planning (Dynamic Consolidation) is the key planning component
- Simultaneous optimization of material and capacity usage within a facility
- Optimal fulfillment of orders based on priorities and due dates
- Intelligent use of alternate resources and operations within a facility
- Consideration of material lifetime expiration

##### Integration:

- MRP systems
- Work-order management systems
- Lot-trace management systems
- Tactical planning systems

##### Value:

- Consistently good customer service
- Increased efficiency (resource utilization)
- Reduced manufacturing cycle time
- Reduced inventory levels
- Reduced planning cycle time
- Increased responsiveness

### *What-if-scenario analysis*

Scope:

- All distinct planning levels

Needs:

- To routinely and accurately answer the following questions over the specified planning horizon: can the supply satisfy all demand, if not why not, what are the alternative supply options, what are the resource bottlenecks, what if a whole facility closes down.

Solution Components:

- Campaign Planning (Dynamic Consolidation) is the key planning component
- Rigorous preparation of the business scenario with the responsible decision-making owners

Integration:

- All planning systems

Value:

- Quick identification of supply chain bottlenecks
- Better risk management for natural disasters or unexpected business incidents
- Proactive testing of the impact on the supply chain of decisions to be made

## **5. CONCLUSIONS**

In this paper we highlighted the crucial role of Campaign Planning in Manufacturing especially in asset intensive industries like pharmaceuticals. Afterwards, we presented the complexity of Campaign Planning and how the dynamic consolidation is superior to the traditional fixed one. In addition, we provided a real-world example of how a top five pharmaceutical company benefited from the dynamic consolidation of Campaign Planning among other things. Finally, we stressed the role of flexible what-if-scenario analysis to further mitigate the manufacturing supply chain's risk.