MODELING RESOURCE CAPACITY FOREFFECTIVE SALES AND OPERATIONS PLANNING - CASE STUDY

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ABSTRACT

Effective Sales and Operations Planning (S&OP) / Integrated Business Planning (IBP) is critical for organizational goals of delivering profit and customer satisfaction by striking a balance between supply and demand. Multiple stakeholders are impacted by the success of S&OP / IBP process. Master schedulers can define an effective master plan, customer service can provide reliable promised date based on master plan, Material planners can better align and utilize the constrained material to the desired objective of the S&OP/IBP process.

Identification and modeling the capacity constraints is one of the building blocks for successful S&OP / IBP process. Accurately identified capacity constraints significantly improve the output of S&OP / IBP process. Well defined and modeled capacity constraints can help establish optimum and reliable master plans.

This article gives insight to an exercise conducted in identification and modeling resource capacity constraints. The article reveals how the rudimentary guidelines impacted identification of the constraints and the impact of these constraints modeled in the system. Further the article discusses a change in perspective that resulted in efficient modeling of resource capacity constraints and the benefits realized by the organization. The article also captures the change management challenges related to the new guidelines established.

Key words: *Sales and Operations Planning (S&OP), Integrated Business Planning (IBP), Resource Constraints, Lead Time Constraints, Supplier Capacity Constraints, Master Scheduling, Detailed Scheduling, Oracle Advanced Supply Chain Planning (ASCP)*

INDRODUCTION

1: Overview of modeling constraints in S&OP and its impact

Sales and operations planning is a cross-functional, collaborative process that sets the guiding path to achieve organization goals. The collaboration of sales, marketing, operation, procurement, and finance is targeted towards defining time-bound, financially viable demand and supply plans. The process is focused on balancing demand and supply by striking a balance between production cost, inventory cost, profits and revenue. The leading ingredient of this process is capacity.

As a part of the process, different teams need to identify capacity constraints like manufacturing teams need to identify resource capacities, distribution teams need to identify lead time and transportation capacities, purchasing teams need to identify supplier capacities. Then the process tries to allocate capacities to demand requirements in order to achieve organization goals. Organization goals can have a significant impact on capacity allocations. For example, capacity allocation to maximize profit can be different than that of maximizing resource utilization.

Identifying capacity constraint levels is crucial for this exercise. Setting up a high number of constraints can make the results very complex to analyze and make decisions on capacity allocations difficult. Setting up too little capacity constraints can make the results simple to interpret but they may not be feasible to implement. Another key factor is the scope of the impact of capacity constraint. While running the capacity allocation exercise for global supply chain, constraints set up at local level may not have any impact. But assessing the impact of the constraint can take away crucial time and efforts of the cross-functional team.

Hence identifying the type of constraint, quantitative values of the constraints and level at which to set up constraint is significant.

2: Types of constraints

Modern supply chains are complex. For a vertically integrated organization, there are several supply chain nodes that need to work together. Each node in the supply chain can have one of the following key constraints that need to be modeled.

- Resource Constraints – Resource capacity constraint is the most common and arguably most important constraint. Resource constraints are often expressed in terms of quantity that can be produced in a time bucket like weeks or months. However, the actual constraint lies in the time duration available for the resources. It is important to understand that even if the constraints are expressed in quantity, it is important to convert it into required resource hours using production rate.

For example: - Assume resource RES-1 can produce 3 items – A, B and C. The resource availability expressed in hours is 40 hours per week. The production rate, which is parts produced per hour, play a key role in production capacity as shown in table below -

Resource - Resource 1					
	WEEK 1	WEEK 2	WEEK 3	WEEK 4	WEEK 5
Resource Availability in Hours	40	40	40	40	40
Item - A - Production Rate / Hour	10	10	10	10	10
Item - B - Production Rate / Hour	15	15	15	15	15
Item - C - Production Rate / Hour	25	25	25	25	25

Max Possible Weekly Production Capacity for					
Item - A	400	400	400	400	400
Item - B	600	600	600	600	600
Item - C	1000	1000	1000	1000	1000

Figure1: Representative data of resource capacity and production rates

It is also important to note that alternate resources also contribute to resource capacity. Alternate resource or substitute resource is resource which can be used in production of an item in case, the resource with first preference does not have enough capacity to fulfill demand or is not available. The resource with first preference is referred to as 'Primary Resource'. Other resources with lower preference are referred to as 'Alternate Resource' or 'Substitute Resource'.

- Lead Time Constraint – General definition of lead time is time duration between start and completion of an activity. Depending on the activity the lead time can be identified as Manufacturing lead time, Transit Lead Time, processing lead time etc. Most important lead time that impacts the supply chain are –
    - Manufacturing Lead Time – This is time taken for completion of manufacturing activities for that item. If the lead time of manufacturing of sub assembly is added to the item, then it is defined as 'Total Manufacturing Lead time'. When time required for purchasing components is also added then it is defined as 'Total Cumulative Lead Time'
    - Transit Lead Time – This is time duration to transfer the items from one location to another location of the organization. Example, time takes to transfer finished goods from manufacturing plant to warehouse or from warehouse to distribution center etc.
    - Purchasing Lead Time – The time taken from placing an order with the supplier till the time goods are received, inspected and certified for use of production.
- Supplier Capacity - Quantity of purchased item supplier committed to supply each time bucket. This also represents the supplier off days when suppliers cannot supply the goods.

3: Setting up resource capacity constraints and impact on S&OP / IBP process

The case study of an organization discusses the impact of setting resource capacity constraints at different levels. The focus of this discussion is resource capacity constraints.

For the supply planning part of the S&OP/IBP process, an Oracle Advanced Supply Chain Planning (ASCP) application is configured. Supply planning calculation process conducted by the application is called 'Planning engine'. The planning engine runs calculations to balance existing supply with demand and recommends new supply orders in order to fulfill the demand.

Oracle ASCP application has 3 different modes –

- Unconstrained – In this mode of planning engine calculation, the engine ignores the resource and lead time capacity constraints. The engine does NOT evaluate capacity of alternate resources. In cases where the requirement of resource hours is higher than available resource hours, the planning engine overloads the resources and issues and exceptions. An exception is an indicator to the planner about unfulfilled conditions. In this case, resource capacity exception is issues indicating planner that there is no sufficient capacity on a primary resource.
- Enforce Demand Due Date (EDD) – In this mode of the planning engine calculation, demand due dates are considered a hard constraint. Capacity constraints can be violated with the issue of exception. Hence the name 'Enforce Demand Due Date (EDD). The engine evaluates the capacity on alternate (or substitute) resources before overloading the primary resource. This need configuration of 'Decision Rules'. Decision rules is instruction to planning engine which alternate options to evaluate. Following options are available as decision rules and depending on business scenario combination can be enabled -

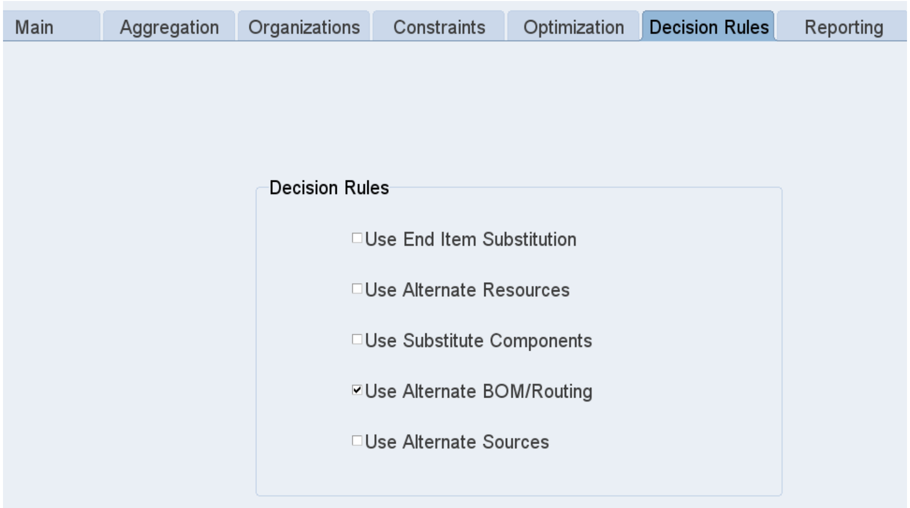

Figure2: Screenshot of Decision Rules tab of ASCP plan

However the engine also issues exception that new recommended orders called 'Planned orders' are using alternate (or substitute resource).

- Enforce Capacity Constraints (ECC) – In this mode of planning engine calculations, capacity constraints are considered hard constraints. Demand fulfillment can be delayed but capacity constraints can not be violated. Hence the name 'Enforce Capacity Constraint' (ECC). In this mode, capacity for primary as well as alternate is evaluated for the demand fulfillment. If there is not enough capacity then demand fulfillment is delayed and a new date is recommended as demand due date. Similar to EDD mode, ECC mode also used decision rules and evaluates the alternate resources, routings or components before delaying the demand fulfillment date.

At the time of implementation of Oracle ASCP application, planners were informed to identify 'Bottleneck Resources' in the respective are. A resource 'Bottleneck Resource' is a resource which, despite running at full capacity, cannot fulfill requested demand quantity. A resource group was defined to identify all the bottleneck resource. This group is called 'Bottleneck Resource Group'. Once planners identified a resource as bottleneck, they assigned the resource to bottleneck resource group. When ASCP planning engine ran, it identified resources assigned to this group as bottleneck and evaluated alternates assigned to these resources as well.

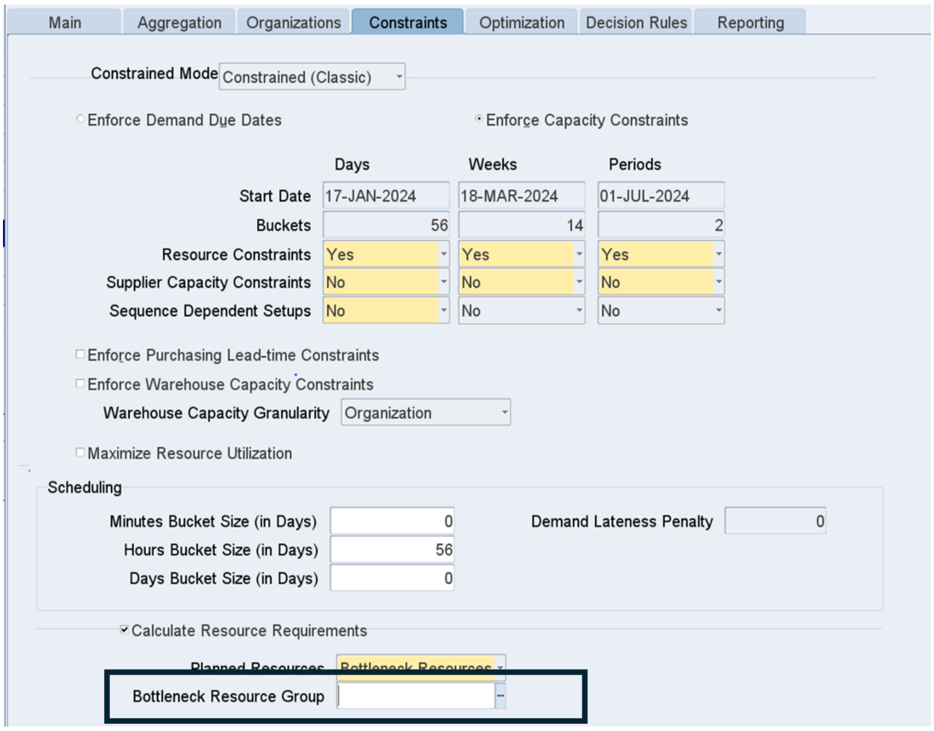

Figure 3 :Screenshot of Constrained tab of ASCP Plan and field to select Bottleneck resource group

The organization is vertically integrated organization where distribution centers are supplied by finished good manufacturing plant, finished good plant is supplied by sub assembly manufacturing plant. Below is representative supply chain of the organization –

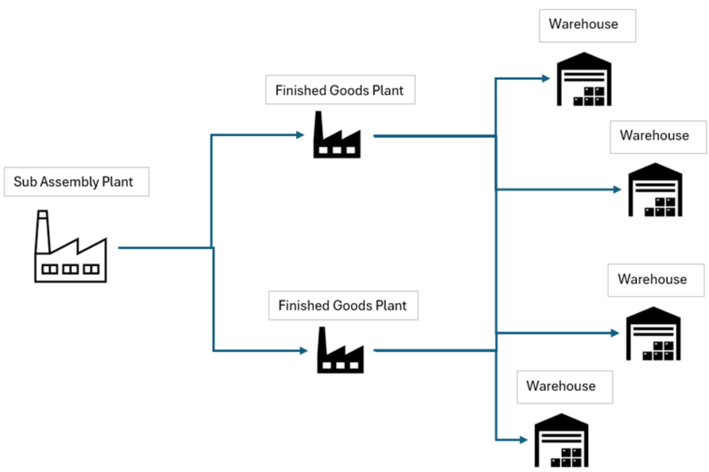

Figure 4: -Representative supply chain for vertically integrated organization.

Now based on the guidelines, planners from all the manufacturing area identified bottlenecks in respective areas and assigned the bottleneck resource group. This resulted in a very high number of bottleneck resources in the system. Since ASCP uses optimization, the resultant solution space has many possible solutions.

Sample screenshot of the solution space with high number of constraints –

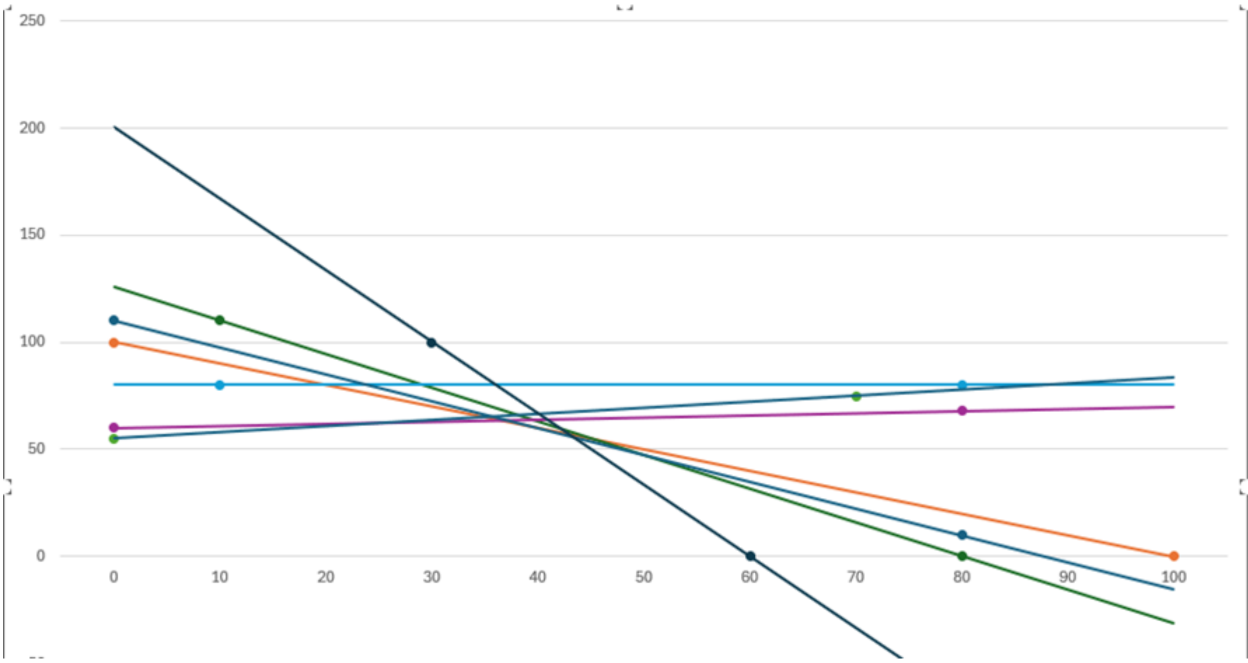

Figure 5: Representative graph of solution space with high number of constraints in optimization

Due to high number of resource capacity constraints modeled, following challenges were faced –

- There was a possibility that the recommended result of product mix on the capacity constrained resources changed with every plan run.
- ASCP issues a high number of exceptions at every level of constraint. Planners were unable to resolve each and every exception.
- The S&OP / IBP monthly review process became very complex. If the team identified delayed demand in ECC plan or overload on a bottleneck resource or underload on and

high value resource, the investigation became very time consuming. Planners have to review and analyze multiple exceptions.

- The team faced delays in resolving all exceptions or the team had to defer resolution of all exceptions. The downside was that the team spent time resolving exceptions with low impact and exceptions with high impact were left unattended.

4: How the new rules were established and modeled and how did they benefit the process?

The S&OP/IBP team conducted brainstorming sessions with focus to reduce and capture only effective constraints. For the brainstorming session following steps were taken –

- Conduct sales data analysis and prepare list of top 10 finished goods with high volume, high profitability and high revenue finished goods
- ASCP Unconstrained plan was run with current forecast and required production volume for the finished goods from the list was captured. ASCP Unconstrained plan considers only primary resources and overloads them if there is no sufficient capacity available.
- The demand then subjected to resource constraints one level at a time. This also considers the capacity available with alternate resources.

For example, assume a finished good goes through 3 levels of manufacturing activities set as critical –

Operation	Resource	Resource hours Available per week	Production Rate Per Hour	Max Weekly Production	Demand Quantity	Fulfilled Quantity in this step	Unfulfilled Demand in this step
Kitting	KITTING-RESOURCE	160	1,500	240,000	180,000	180,000	-
Primary Assembly Operation	Resource-1	40	2,000	80,000	180,000	80,000	100,000

Operation	Resource	Resource hours Available per week	Production Rate Per Hour	Max Weekly Production	Demand Quantity	Fulfilled Quantity in this step	Unfulfilled Demand in this step
Final Assembly Operation	Resource-2	80	1,200	96,000	80,000	80,000	-

Figure 6: Table with example of demand fulfilment calculations

- In the initial stages when analysis was done for finished goods, redundant constraints were easily identified. In the above example, constraint on 'Resource-2' is redundant because 'Resource-1' has lowest max production volume per week. Hence setting up 'Resource-1' as constraint is sufficient.

  However when the exercise reached a step to evaluate resource capacity constraints for sub assembly then the team hit a roadblock. Implementing the evaluation steps on sub assembly resource constraints posted following challenges –

- Some of the bottleneck resources were aggregate resources. For Oracle ASCP this provided aggregate level capacity.

For example, there are 10 different molding machines, and they work with tool. One molding machine can be paired with multiple tools. Depending on the pairing of the machine with tool the machine produces different sub-assemblies. But in the system, only one resource was setup as aggregate resource to represent capacity of 10 machines.

- However, tools need to be set up at an individual level. If each mold is also set up as an individual resource then the machine – tool combinations would have become large number. For every sub assembly large number of alternate combinations need to be maintained.
- But not every mold – tool pairing is approved for every sub assembly. Hence after setting up aggregate resource the capacity for the sub assembly is inflated.

This resulted in conflicting setups. On one hand setting up aggregate resource helps in easy maintenance of data, but represents incorrect capacity numbers. On the other hand, setting up each individual resource helped in correct capacity numbers but then resulted in large number of combinations, in some cases more than 30 combinations, creating data maintenance issues.

The team decided to evaluate another approach of setting up dummy resources that control the capacity numbers provided by production. The team created group of items that shared multiple critical resources. Then for the group, production volume for each week was agreed with production. Then based on the agreed production per week, production rate for the dummy resource was calculated. Then the dummy resource with calculate production rate was assigned to item.

An example of setting up of dummy resource –

Resource Name	Hours Available Per Week	Target production per week	Production Per Hour
DUMMY-CAPACITY- GROUP-1	40	160,000	4,000

Figure 7: Table for example calculation of production rate for dummy resource

Once the dummy capacity resource is setup and assigned as critical resource, other resources are removed as critical resource. The dummy resource is now controlling the capacity of the group of resources.

For example,

Item Name	Actual Production Rate	Required Quantity	Required Hours	Set Production Rate	Set Production Hours
ITEM-A	4,500	80,000	17.78	4,000	20
ITEM-B	3,000	40,000	13.33	4,000	10
ITEM-C	3,500	40,000	11.43	4,000	10
	TOTAL	160,000	42.5		40

Figure 8: Table with example calculation with dummy resource production rate

Now ASCP controls the product mix as well to deliver the targeted production quantity per week.

The setting up of dummy capacity resources realized following advantages –

- There are less constraints modeled. This simplified the solution space and the recommended product mix changes are minimized. Below is representative screenshot of constraints after simplification –
- Exception generated in Oracle ASCP for resource constraints are reduced and the planners can focus more on the resolution of the exceptions.
- S&OP capacity discussions become streamlined because the resource capacity points are less and reliable since production rates are calculated based on target production rated committed by production planning team.
- The exercise helped the organization streamline the roles of master schedulers and production schedulers. With the overall capacity number fixed, master schedulers can focus on getting the optimum product mix. Production schedulers can then focus and assign resources to the items to get the desired production based on product mix.
- The exceptions if any captured production schedulers were discussed and resolved during S&OP/IBP meetings.

CONCLUSION:

Effective S&OP/IBP process gives a competitive advantage to an organization as it helps in directing the cross-functional efforts towards organizational goal. The focus of S&OP/IBP process is to define a plan of supply and demand balance that is backed by capacity constraints.

Different types of constraints can be modeled in Oracle Advanced Supply Chain planning and the plan mode can decide the desired outcome for the constraints. Modeling resource capacity constraints as bottleneck resources is important.

Identifying correct level and optimum number of resource capacity constraint is vital to get stable and feasible output of the plan runs. Modeling the correct resource constraint can drastically help improve the quality of S&OP/IBP process.

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