Technology optimization and change management for successful digital supply chains

Chapter 11: Capacity planning in digital age:
A process to prepare to meet the volatile demand
Technology Optimization and Change Management for Successful Digital Supply Chains

Ehap Sabri
*KPMG LLP, USA & University of Texas at Dallas, USA*
Chapter 11
Capacity Planning in Digital Age: A Process to Prepare to Meet the Volatile Demand

Amit Gupta
KPMG LLP, USA

ABSTRACT

This chapter answers the following questions: 1) What is the capacity planning process? 2) Why do companies need to perform capacity planning? 3) What are current challenges in the capacity planning process? 4) What are different levels in the capacity planning? 5) What are planning zones? 6) How does capacity planning implementation journey look like? In the chapter, the author touches some of the basics of the capacity planning and then goes into advance level in the capacity planning. The chapter expects readers to have a basic knowledge of the capacity planning.

LITERATURE REVIEW

Capacity planning has been around for a very long time; earlier businesses used to plan factory throughput or the number of customers they can serve to buy equipment or hire labor. Initially, capacity planning span was a factory to a workstation. When supply chains began to move out of organizations’ four walls, a need for holistic capacity planning manifested, with several challenges. The long lead time associated with outsourcing introduced limited flexibility and higher inventory, for both safety stock and cycle stock. Global footprints led to inconsistent factory utilization, which highlighted the need for global planning and visibility; however, with limited software sophistication, the focus remained on optimizing a factory and pressure feeding-plants and suppliers to support the plan. With today’s digital capabilities, an organization can not only link its strategic plan to a detailed execution-level capacity plan, but also gain visibility outside its four walls to ensure the complete network can support its strategic plan.

To link the strategic plan to the operational plan and support specific decision needs, the capacity planning process has broken into multiple levels. Each level has different granularity and frequency and has a distinct purpose. While APICS divides end-to-end capacity planning into four levels (resources requirement planning, rough-cut capacity planning, capacity requirement planning, and input/output control), this chapter divides end-to-end capacity planning into five levels with strategic capacity planning as an additional level to align corporate objectives with the execution plan. The variations in the number of levels have existed; for example, Bram Desmet of Solventure and Adrian Bentley of McBride divided the capacity planning process into five levels in a webinar. The picture below shows the proposed five levels of capacity planning.

Five levels in the capacity planning provide a holistic, top-down view of the capacity—validating and verifying the process’s end goal at each stage and disseminating the information to the next level to make execution-level decisions. For example, leadership defined a long-term goal in strategic capacity planning that is disaggregated into a yearly plan considering market conditions in the annual budget planning process. Following the budget, rough-cut capacity planning and capacity requirement planning generate and track a tactical plan to achieve the annual plan. Finally, detailed production planning adds execution-level detail for day-to-day execution. The level of sophistication and need of supporting technology increase as the process moves from level 1 to level 5.

A subsequent section provides background information, and after the background, the chapter expands five levels of capacity planning process and provides a maturity model for organizations to assess their capabilities.

Figure 1. Capacity planning levels
Capacity Planning in Digital Age

BACKGROUND

Capacity Definition

Capacity is the output of a resource for a period. A resource can be a manufacturing plant, an assembly line, warehouse space, a truck, or any equipment that assists in producing a product or delivering a service. Resources can exist within an organization’s four walls or at companies supplying components, raw materials, or supporting select operations. For example, Samsung© builds components for its Galaxy© product line at its facilities in South Korea while it also uses Foxconn© for assembly operations in China; therefore, Samsung has internal capacities in South Korea and external capacities at Foxconn in China.

The following diagram shows a simple linear supply chain with five nodes—supplier, manufacturing, transportation, warehouse, and store. Each node in this supply chain has one or more capacities. For example, the raw material supplier, a mining company, has capacity in the form of labor and heavy machinery to extract ore, such as an earthmover that can move 1,000-tons of dirt per hour. The transportation company has trucking capacities to support the movement of the goods, such as a truck that has a total of 1,000 cubic feet of space or can move a 25-ton weight.

Capacity Planning

Capacity planning is a technique to plan optimum resource levels to meet future demand in all market conditions. The key to effective capacity planning is the optimal level of resources because excess capacity reduces investment available to other functions, while inadequate capacity causes lost sales and unhappy customers.

Organizations can make minor capacity adjustments through overtime, idle time, or lower run rate to respond to short-term demand variations. On the other hand, large capacity variations, such as opening a distribution center to add storage space or shutting down a plant to eliminate excess capacity, are done only in large chunks with an associated long lead time—a few months to several years.

Figure 2. Different types of capacities in the supply chain
Most of the examples and concepts in this chapter are manufacturing-organization focused; however, similar concepts are applicable to service organizations. Additionally, a majority of the concepts mentioned in the chapter are aligned with APICS\textsuperscript{2} definitions with some variations based on the author’s 15 years of experience in the field at various organizations.

Now, with the basic understating of capacity planning, the discussion is moved to understand the need for a capacity planning process and the implications when the process is not executed aptly.

**Need for Capacity Planning**

If demand was uniform or resources were unconstrained, the capacity planning process would be a trivial task; however, except for a few government agencies, such as tax authorities, product or service forecast has low accuracy and high volatility with access to only finite resources to meet this demand. Coping with demand volatility and making long-term decisions with hundreds of unknowns while mitigating risks make the capacity planning process challenging. Some of the challenges of capacity decisions are as follows:

- **Volatile demand**: As mentioned previously, except for a few government agencies, organizations deal with demand volatility (peaks and troughs) and timing and accuracy. In current market conditions, where shorter product life cycles are becoming the norm and threatening previously optimized flows, achieving a comfortable demand accuracy for a sustained period is turning out to be more challenging; as a result, companies need to be prepared, on the supply side, to absorb some of the demand challenges.

- **SKU proliferation**: Online sales channels offering customized products with unprecedented choices are leaving both online and offline players with a large number of products to manage. On the supply side, additional product variations complicate the capacity planning process because factories now needed to run a large number of products leveraging the same resources while minimizing changeovers. With SKU proliferation, lack of a defined capacity planning process and the absence of an enabling technology to execute the process may lead to higher costs and lost sales.

- **Shorter product life cycle**: It is not obvious, but a shorter product life cycle has large implications for capacity planning as supply organization constantly need to refresh capacities to phase out old products and launch new products.

- **Need for visibility**: Digitization of the supply chain necessitates high supply chain visibility so that companies can commit to customers confidently; however, in the absence of the right tools together with SKU proliferation, providing true visibility to end nodes in the supply chain is challenging.

- **The influx of new digital capabilities**: Internet of Things (IoT) sensors in machines, radio-frequency identification (RFID), and collaboration technologies are enabling organizations to share and receive information to respond better to market needs; however, many organizations are not prepared to harness the new information that may cause them to lose to a competitor who built these capabilities.

Given the challenges outlined above and their implications for the prospects of the organization, a better capacity planning process can not only boost revenue and lower capital requirement, but also provide a true competitive advantage.
Challenges in Capacity Planning

Realizing the importance of capacity planning, many organizations have begun focusing on improving the capacity planning process; however, organizations are facing several challenges in managing the process efficiently. The list below highlights some of the challenges.

1. **Defining the right level for planning:** Every organization performs capacity planning in some shape or form; however, conducting at a level that puts forth the right detail to support leadership to make the right decisions is the ultimate objective of the process. This may sound simple, but not many organizations are able to achieve it. For example, capacity planning for high-level resources, such as total factory capacity to make shoes at a shoe manufacturer, can be used to determine the need to build a new factory or expand the factory; however, this high-level information cannot help in answering if the company can deliver 10,000 shoes in the month of July. Many companies are performing capacity planning either at a very high level for long-range strategic planning or performing at a detailed factory planning level, which is a complex, resource-intensive process and challenging to rapidly respond to market fluctuations. Defining the right levels for capacity planning is vital to support the right decisions.

2. **Availability of the right data:** The capacity planning process relies heavily on having the right data with sufficient detail to support the process, such as time-phased capacity information for resources, products capacity usage etc. In the absence of correct data, the process generates inaccurate results leading to wrong decisions.

3. **Defining the right hierarchy:** To perform capacity planning at different levels of aggregation to support different decisions, organizations need the right levels in the product, location, geography, and time hierarchies. Right levels in the hierarchies enable aggregation and disaggregation for different functional groups to view the same information at a different level. For example, Finance views total revenue at the business unit level while the S&OP team views revenue by product lines.

4. **Set up the right organization:** Many organizations lack a dedicated group to manage the complete capacity planning process. Several groups support part of the process, but a single group does not cover the holistic capacity picture, which cuts through cross-functional boundaries. Lack of the right organization structure leaves the organization with localized suboptimal results.

Capacity Planning Levels, Maturity, and Implementation

Before discussing each level of capacity planning mentioned in Figure 1, it is important to understand some of the concepts related to capacity planning.

Capacity Unit of Measure

Capacity is measured using various units of measure. Three commonly used measures are as follows:

1. **Run rate:** Run rate for a machine is defined as total output produced in a defined time, for example, 200 units/minute for an injection-modeling machine or 40 tons of steel per hour. Run rate is mostly used to quote capacity for resources producing a single line of product. For example, a simple one-liter water bottle filling machine can fill 4,000 bottles in an hour.
2. **Total available time**: Some resources can produce a variety of products, and each product can have a different run rate on the resource. For example, a lathe machine can produce 20 small gears per hour, while it can produce only 2 pistons per hour. Depending on the type of product, the resource’s run rate can vary; therefore, instead of quoting the resource’s capacity as multiple run rates, the resource’s capacity can be quoted as total available hours, such as 18 available hours per day.

3. **Space**: Capacity of warehouses, retail stores, service organizations, etc., are defined in square feet.

**Capacity Calendar**

Due to maintenance activity or operator’s availability, or various other reasons, a resource’s capacity can vary week over week. To represent capacity variations, capacity is defined in a calendar format, which provides the flexibility to maintain different capacity for different periods. For example, a gear-cutting machine can be available 18 hours per day for most days, but for a few days, due to maintenance and operators’ availability, it can be available only for 8 hours.

Additionally, resources have two types of capacities—design capacity and effective capacity. Design capacity is the maximum output of the resource while effective capacity is the capacity that can be generated consistently over a long period. The reason for two different types of capacities is that resources can run at maximum capacity only for a short time as running at maximum capacity for a prolonged time may cause breakage, which results in downtime or reduced capacity. For resource load planning, effective capacity is used. The table below shows an example of an effective capacity calendar of a lathe machine.

**Planning Horizon and Planning Buckets**

The planning horizon is the period of time in the future that an organization plans capacity. Planning horizon can be 4 weeks to 5+ years, depending on the level of the capacity planning. The planning horizon is divided into planning buckets. Planning buckets can be daily, weekly, monthly, quarterly, or yearly. Most often, daily and weekly planning buckets are used for short-term planning, such as detailed production at Level 5 in Figure 1, where detailed information is necessary to execute orders in a factory or place a raw material order to support production. Monthly and quarterly buckets are used primarily for a medium-term planning horizon, while yearly buckets are used for long-term planning. Based on the organization structure and product type, organizations can define the length of the planning horizon and planning bucket.

The following picture shows the five-year planning horizon with weekly, monthly, and quarterly buckets. Different planning buckets in the same horizon are called a mixed bucket horizon or telescoping buckets—more detail in near-term and time aggregation later to reduce uncertainty.

**Table 1. Capacity calendar**

<table>
<thead>
<tr>
<th>Lathe capacity</th>
<th>Week 1</th>
<th>Week 2</th>
<th>Week 3</th>
<th>Week 4</th>
<th>Week 5</th>
<th>Week 6</th>
<th>Week 7</th>
<th>Week 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hour per day</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>18</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Number of days</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Total weekly capacity (hours)</td>
<td>90</td>
<td>90</td>
<td>90</td>
<td>72</td>
<td>40</td>
<td>40</td>
<td>60</td>
<td>90</td>
</tr>
</tbody>
</table>
Capacity Planning in Digital Age

Top-Down Approach to Capacity Planning

At the beginning of the chapter, Figure 1 introduced five levels of capacity planning. Each level of capacity planning is done to meet a specific objective and to make specific decisions. The section provides detail of each level.

- **Strategic Capacity Planning:** Strategic capacity planning is tied to the organization’s strategic planning process, which defines strategic direction for the next 3 to 5+ years. As a part of the strategic planning process, strategic capacity planning helps in understanding the total capacity required to achieve the organization’s long-term growth plan. Strategic capacity planning is performed for overall capability considering plants’, subcontractors’, and suppliers’ capacity to understand, at a high level, if the supply chain has the required throughput to support the growth plan. Strategic capacity planning is performed yearly for a 3 to 5-year planning horizon (in the case of auto OEM, 5 to 10 years) in quarterly or yearly planning buckets. The objective of strategic capacity planning is to enable leadership to make large capital investment decisions, such as opening a new factory or building new supplier capability in 2 years, etc.

  For example, a shoe manufacturer has $5 billion in annual revenue and has factories to fulfill $5.5 billion revenue to accommodate growth. A new CEO joins the company and sets up a new target for the next five years: achieve 4 percent compounded growth year over year to achieve $6 billion in revenue by the fifth year. To support this long-term growth plan, in the strategic capacity planning process, leadership validates the supply organization’s capability to support the growth and makes capital investment decisions to fill the gap. Based on revenue projections year-over-year for five years (Table 2), the organization will face a $500 million revenue shortfall for the fifth year and total $870 million cumulative revenue gaps over 5 years due to capacity shortages. To fill these capacity shortages, leadership has multiple options: expand capacity at the beginning of year 2, buy a supplier in year 3, open a new factory in year 3, improve performance of existing capacity, and so on.

- **Annual Budget Planning:** Annual budget planning or annual operating planning occurs yearly to define goals and the operating plan for the whole organization for the upcoming financial year. It is an organization-wide process with the supply chain group as one of the participants. Finance typically leads the process with inputs from various business units and functional groups. In this process, the leadership defines revenue targets, which translate into demand targets for different business units to achieve the collective annual plan. Based on demand targets, the supply planning group identifies, in collaboration with procurement, an operating plan to fulfill the demand and gaps in current capacities. The supply planning group presents the operating plan and capacity
gaps to the supply chain leadership to obtain the operating budget and investment to fill any capacity gaps, such as for acquiring a new machine, hiring additional labor, etc. Annual budget planning is performed in quarterly buckets and tracked to quarter-ends in a financial year.

For example, this year, the shoe manufacturer in the previous example is targeting to achieve $5.2 billion in revenue, 4 percent or $200 million above last year’s plan. To meet the additional revenue goal, the organization is planning to introduce a new product line. The supply planning group, responsible for capacity, determines that the organization would need to expand capacity of three assembly lines and buy three new machines to support the additional revenue. During the annual budget planning process, the supply planning group will produce the plan to expand capacity to the leadership. Based on the proposal, leadership may assign capital budget to expand the capacity.

- **Rough-Cut Capacity Planning**: Rough-cut capacity planning (RCCP) is part of a mature monthly sales and operation (S&OP) process. A key objective of S&OP is to get the product volume right considering consensus demand and available capacity; therefore, RCCP, which assists the S&OP team in validating capacity, is done at an aggregated level, such as at the product family level. Since RCCP is performed at an aggregated level, resources in RCCP are also aggregated to enable the S&OP team to make tradeoffs among product families to maximize fill rate, increase margin, and fill any gaps between the annual operating plan and current operational plan. Here is a guideline to select resources for RCCP.
  - Factory throughput can be one of the constraints.
  - For select strategic products, overall output can be a constraint.
  - Overall product output can be a constraint when a product is sourced from more than one source.
  - An aggregated resource, which dictates a factory or product output; for example, Bliss press capacity in forging operation or molding capacity for a foundry or plastic part manufacturing

RCCP is performed in monthly buckets for the next 18- to 24-month planning horizon, and if the horizon is longer than 24 months, then in quarterly buckets. The aim of RCCP is to highlight demand/supply gaps in midterm (outside of the 3-month horizon) and assist in filling the gaps using different strategies, such as prebuilding to accommodate peak demand, offloading volume to suppliers, etc. The output of the RCCP is called production requirements.

---

**Table 2. Strategic capacity planning analysis example and resolution options**

<table>
<thead>
<tr>
<th>Year</th>
<th>Current year</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>$5.0B</td>
<td>$5.2B</td>
<td>$5.41B</td>
<td>$5.62B</td>
<td>$5.85B</td>
<td>$6.0B</td>
</tr>
<tr>
<td>Supply capacity</td>
<td>$5.5B</td>
<td>$5.5B</td>
<td>$5.50B</td>
<td>$5.50B</td>
<td>$5.50B</td>
<td>$5.5B</td>
</tr>
<tr>
<td>Shortfall</td>
<td>($120M)</td>
<td></td>
<td>($250M)</td>
<td></td>
<td>($500M)</td>
<td></td>
</tr>
<tr>
<td>Cumulative shortfall</td>
<td>($120M)</td>
<td></td>
<td>($370M)</td>
<td></td>
<td>($870M)</td>
<td></td>
</tr>
<tr>
<td>Plan to fill the shortfall</td>
<td>Initiate improvement</td>
<td>Expand the plant</td>
<td>Buy a supplier</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
RCCP is one of the parts of the larger monthly S&OP process and S&OP is a large topic in itself. Without going into detail of S&OP, the following depiction will expand the shoe manufacturer example to demonstrate RCCP briefly.

Sales, operations, marketing, and finance together finalize the annual plan and break it into a monthly or quarterly plan for execution and tracking. Additionally, to plan for the longer term, the planning horizon is extended to 2 years using projections considering the strategic plan, demand history, product roadmap, and market conductions.

In RCCP, first demand planning and supply planning bring their best plan along with several scenarios to fill any revenue gaps or eliminate supply shortages. For the review meeting with leadership, the demand plan is aggregated to Business Units (BU) and families to assess the gap between unconstrained demand plan and annual plan and supply plan is aggregated to view supply shortages for a BU and a family.

Table 4 shows demand, supply, and supply gaps for one product family, Sports Shoe, in both units and dollars. Showing the demand plan in both units and dollars is important because different groups talk in a different unit of measure. For example, Finance cares about revenue while demand planning cares about units; therefore, aligning groups in showing the plan in their unit of measure helps in making quick decisions.

In the leadership review meeting, apart from highlighting supply gaps, the supply planning group proposes various scenarios to fill those gaps, such as run plants overtime for three days in a month, or if plants are already running at the maximum capacity, shift the load to a supplier, and so on.

After resolving supply gaps for individual families, leadership reviews revenue gaps between the demand plan and annual plan (an example is shown in Table 5) and reviews proposed options to fill gaps, such as run a promotion to close revenue gaps or launch a product early, etc. After the review, leadership approves a plan for the execution.

Table 3. Annual plan example

<table>
<thead>
<tr>
<th>In million $</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>..</th>
<th>M23</th>
<th>M24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual plan</td>
<td>$100</td>
<td>$100</td>
<td>$100</td>
<td>$110</td>
<td>$110</td>
<td>$110</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
</tbody>
</table>

Table 4. Family level supply gaps example

<table>
<thead>
<tr>
<th>Sports shoe</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>..</th>
<th>M23</th>
<th>M24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand plan ($)</td>
<td>$30M</td>
<td>$35M</td>
<td>$33M</td>
<td>$34M</td>
<td>$36M</td>
<td>$37M</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Demand plan (units)</td>
<td>1.2M</td>
<td>1.4M</td>
<td>1.32M</td>
<td>1.36M</td>
<td>1.44M</td>
<td>1.48M</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Supply plan unit ($)</td>
<td>$30M</td>
<td>$32.5M</td>
<td>$32.5M</td>
<td>$32.5M</td>
<td>$32.5M</td>
<td>$35M</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Supply plan unit (s)</td>
<td>1.2M</td>
<td>1.3M</td>
<td>1.3M</td>
<td>1.3M</td>
<td>1.3M</td>
<td>1.4M</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Supply gap ($)</td>
<td>($2.5M)</td>
<td>($0.5M)</td>
<td>($1.5M)</td>
<td>($3.5M)</td>
<td>($2M)</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Supply gap (units)</td>
<td>(0.1M)</td>
<td>(0.02M)</td>
<td>(0.06M)</td>
<td>(0.14M)</td>
<td>(0.08M)</td>
<td>..</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
</tbody>
</table>
• **Capacity Requirement Planning**: Capacity requirement planning (CRP) is performed as a part of the master planning process. In master planning, the output of RCCP—production requirement at an aggregated volume level—is used to plan individual products to drive a master production schedule (MPS) at an item or SKU level. At an aggregate level, MPS should match with the production requirement of the S&OP process. CRP considers only key bottleneck resources; therefore, it should not be confused with detailed production planning. The number of resources in CRP is generally more than RCCP but fewer than the detailed production planning process, which considers most of the resources. For example, RCCP may consider total molding capacity as a consolidated capacity constraint, while CRP may further divide molding into three constraints, divided by tonnages, such as 1000 ton, 2000 ton, or 5000 ton. Unlike RCCP, CRP can plan some of the detailed capacities because the demand in CRP is at item level; thus, the load on an individual machine can be determined to identify load on the capacity.

CRP is performed in weekly buckets for next the 2- to 6-month planning horizon, and monthly buckets following the weekly buckets. Since CRP input—production plan—is in monthly buckets, it needs to be broken into weekly buckets for the first few weekly buckets. Monthly bucket to weekly buckets can be done in different ways; for example, equally to all weeks or a specific percentage for each week.

The aim of CRP is to understand the short-term production plan for the next few months so that procurement can order materials and resources. The output of CRP—MPS—is used for alignment between sales and production—the customer representative team uses it to make customer promises while plants and vendors use it as an expected production plan to prepare raw materials and resources.

A question that is most often asked about CRP is “Which resources should be the part of the CRP process?” A simple guideline is to include the constraints that can give sufficient confidence in committing the production plan to the sales team while avoiding getting into the complex details of production planning. Here are a few additional guidelines to select resources for CRP:

- Consider bottleneck resources that often hit their ceiling.
- Plan resources at an aggregated level, not at an individual tool level.
- Avoid labor as a constraint; however, if labor is a major roadblock, consider leveraging it in some other form, such as a total number of hours.
- Consider selected long lead-time parts or raw materials that often pose scheduling challenges.

<table>
<thead>
<tr>
<th></th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
<th>M5</th>
<th>M6</th>
<th>..</th>
<th>M23</th>
<th>M24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sport shoe</td>
<td>$30M</td>
<td>$32.5M</td>
<td>$32.5M</td>
<td>$32.5M</td>
<td>$32.5M</td>
<td>$35.0M</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Formal shoe</td>
<td>$20M</td>
<td>$25.0M</td>
<td>$30.0M</td>
<td>$35.0M</td>
<td>$35.0M</td>
<td>$34.0M</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Casual shoe</td>
<td>$52M</td>
<td>$40.0M</td>
<td>$39.0M</td>
<td>$39.0M</td>
<td>$38.0M</td>
<td>$38.0M</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Total plan</td>
<td>$102M</td>
<td>$97.5M</td>
<td>$101.5M</td>
<td>$106.5M</td>
<td>$105.5M</td>
<td>$107M</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Annual plan</td>
<td>$100</td>
<td>$100</td>
<td>$100</td>
<td>$110</td>
<td>$110</td>
<td>$110</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Gap</td>
<td>$2M</td>
<td>($2.5M)</td>
<td>$1.5M</td>
<td>($3.5M)</td>
<td>($4.5M)</td>
<td>($3.0M)</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
<tr>
<td>Cumulative gap</td>
<td>$2M</td>
<td>($0.5M)</td>
<td>$1.0M</td>
<td>($2.5M)</td>
<td>($7.0M)</td>
<td>($10.0M)</td>
<td>..</td>
<td>..</td>
<td>..</td>
</tr>
</tbody>
</table>
In CRP, and also in RCCP and detailed production planning, resource constraints are applied in two ways: soft constraints and hard constraints. The difference between two types of constraints is overloading—hard constraints cannot be loaded more than 100 percent while soft constraints can be loaded more than 100 percent. The reason for overloading soft constraints is to alert the planners to overloading and have the planner identify an alternate, which can be expediting material by paying premium freight or using another supplier, etc. In the case of hard constraints, if the constraint hits 100 percent, the system seeks for unused capacity in adjacent planning buckets, and if it cannot find available capacity, it alerts the planner to unresolved capacity gaps.

The output of the CRP process is MPS, which feeds the detailed production planning process. Additionally, MPS drives material requirement planning (MRP) to release purchase orders to suppliers or change existing purchase order, for example – push out, pull in, or cancel a purchase order. The CRP process is demonstrated using the shoe manufacturing company.

In CRP, production plan of families—sports shoes, formal shoes, and casual shoes—is disaggregated into the product-level production plan to model and validate selected critical bottleneck resources. The table below shows CRP analysis on sewing capacity. While weeks 2 and 3 have excess capacity, weeks 4, 5, 7, and 8 have a capacity shortage. To balance the capacity load, the capacity planner may pull forward some load of week 4 to weeks 2 and 3, week 7 load to week 6, and run overtime or extra shifts in week 8. While this example shows manual capacity balancing, modern capacity planning systems can perform this task automatically.

After balancing the bottleneck critical resources, the final master production schedule (MPS) is released to detailed production planning for execution.

- **Detailed Production Planning**: Detailed production planning uses MPS as an input and develops a production plan at the daily-level detail. In detailed production planning, all major resources are considered to plan a full production day. Detailed production planning runs weekly (rerun daily for production misses and for minor changes) to plan for the whole week in daily or weekly planning buckets. The output of detailed production planning is shared with the shop floor to schedule production, which drives material release orders to warehouses to draw the material. Detailed production planning is a time- and resource-intensive process; therefore, the focus on detailed production planning is only 2 to 5 weeks planning horizon in daily buckets.

### Table 6. Resource capacity example

<table>
<thead>
<tr>
<th>Sewing capacity (hrs.)</th>
<th>Wk 1</th>
<th>Wk 2</th>
<th>Wk 3</th>
<th>Wk 4</th>
<th>Wk 5</th>
<th>Wk 6</th>
<th>Wk 7</th>
<th>Wk 8</th>
<th>..</th>
<th>M 23</th>
<th>M 24</th>
</tr>
</thead>
<tbody>
<tr>
<td>Available capacity</td>
<td>20k</td>
<td>20k</td>
<td>20k</td>
<td>20k</td>
<td>20k</td>
<td>20k</td>
<td>20k</td>
<td>20k</td>
<td>..</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>Required load</td>
<td>19k</td>
<td>19k</td>
<td>22k</td>
<td>21k</td>
<td>19k</td>
<td>21k</td>
<td>22k</td>
<td>21k</td>
<td>..</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>Gap</td>
<td>1k</td>
<td>1k</td>
<td>(2k)</td>
<td>(1k)</td>
<td>1k</td>
<td>(1k)</td>
<td>(2k)</td>
<td>1k</td>
<td>..</td>
<td>…</td>
<td>…</td>
</tr>
<tr>
<td>Cumulative gap</td>
<td>1k</td>
<td>2k</td>
<td>0</td>
<td>(1k)</td>
<td>0</td>
<td>(1k)</td>
<td>(3k)</td>
<td>…</td>
<td>..</td>
<td>…</td>
<td>…</td>
</tr>
</tbody>
</table>
Some smaller companies or companies with simpler manufacturing skip detailed production planning and move to factory scheduling directly. If these companies have a sophisticated system that incorporates the detailed production planning in the CRP, they can execute the process; however, if they are planning manually, they will eventually spend more time in CRP to balance the plan, which makes the process rigid to respond to the market demand.

Using the shoe manufacturer example, the detailed production planning process is illustrated subsequently.

After receiving MPS for a specific shoe, the production planner creates a short-term production plan for 4 to 5 weeks in daily buckets. In detailed production planning, the production planner checks capacities of major factory resources that may constrain the plan including labor resources to run lines.

In Table 7, due to sewing capacity shortage on D2, the production planner can move some of the units to D1 and D3.

**Planning Zones and Controls**

With the different planning levels, a discussion on planning zones cannot be omitted as the zones drive change types in the capacity plan. The planning organization defines rules for making changes in the plan in a planning zone and establishes governance to manage the zones. A planning horizon can be divided into three planning zones:—frozen, firm, and free—with a varying time horizon for each zone. Three planning zones are tied to the last three levels of capacity planning levels—detailed production planning to frozen zone, master production planning to firm zone, and RCCP with free zone.

**Table 7. Detailed capacity example**

<table>
<thead>
<tr>
<th>RS-001XBN</th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>D6</th>
<th>..</th>
<th>D27</th>
<th>D28</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production plan</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>1,000</td>
<td>..</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewing requirement</td>
<td>83h</td>
<td>83h</td>
<td>83h</td>
<td>83h</td>
<td>83h</td>
<td>83h</td>
<td>..</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sewing available</td>
<td>200h</td>
<td>10h</td>
<td>100h</td>
<td>80h</td>
<td>100h</td>
<td>100h</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembly hours required</td>
<td>167h</td>
<td>167h</td>
<td>167h</td>
<td>167h</td>
<td>167h</td>
<td>167h</td>
<td>..</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Assembly hours available</td>
<td>200h</td>
<td>100h</td>
<td>200h</td>
<td>200h</td>
<td>200h</td>
<td>200h</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
• **Frozen Zone:** Frozen zone, as the name suggests, does not allow too many changes. Production planned in the frozen zone, once committed, mostly remains unchanged with some exceptions with a valid reason and approvals. Frozen production plan in the short term provides the manufacturing stability to commit resources internally and externally. Production planner and production managers control the frozen zone. Any change in a quantity larger than a certain percentage in the frozen zone needs production manager approval.

• **Firm Zone:** Firm zone provides a little flexibility to accommodate a moderate amount of changes because not all sources in the firm zone duration are committed to the production; however, the long lead-time materials are already ordered for the production in the firm zone that restricts large changes without expediting material. Master planners, jointly with production managers and procurement managers, control the firm zone. Tactical demand and supply weekly/bi-weekly meetings with sales and marketing perspective provide guidelines and ensure both manufacturing and customer priorities stay in equilibrium.

• **Free Zone:** Free zone is for long-term planning and visibility. No commitments are made in the free zone and the majority of the changes, within the overall capacity level, can be accommodated. Supply chain leadership controls the free zone and manages through the monthly S&OP process.

In frozen and firm zones, available and committed supply influences the demand (what can be fulfilled based on available resources), while in the free zone, demand influences supply (what supply should be arranged).

**Capacity Utilization Tracking and Identifying Resources for Planning**

Resources capacity is measured in utilization percentages; the higher the utilization the better the cost efficiencies; however, utilization above 90 percent denotes close to full utilization and inability to accommodate any maintenance downtime or short-term demand changes.

Resource utilization = \( \frac{\text{Used capacity}}{\text{Available capacity}} \times 100 \)
In capacity planning, keeping a history of resource utilization month over month is useful in identifying a trend in resource loading, which can help in identifying resources for RCCP and CRP. Maintaining the history of both high utilization and low utilization is also useful in determining the list of resources for the planning.

A challenge in tracking the utilization is identifying the right level and measuring in near real time to make it actionable. This issue can be addressed by deploying some of the digital technologies and business intelligence (BI) tools. Digital technologies, such as IoT, RFID, and factory collaboration, can provide constant availability of resources and throughput, which can be captured in BI tools and displayed in a dashboard for planners’ actions. Additionally, these digital signals can be fed into the planning system to identify the impact of capacity issues in fulfilled demands. To measure at the right level, it is better to collect the data at the lowest level and leverage BI tools to provide planners capabilities to view metrics at different aggregations; for example, at line level for production planner and at plant level for plant manager or S&OP planner.

Implement the Capacity Planning Process

This section provides a high-level capacity planning maturity model for companies to assess their current maturity level and a brief implementation approach for them to move to a higher level. Since the maturity model in this chapter considered only high-level processes, companies will be benefitted by further assessing their maturity within each level on four dimensions—process, system, organization, and delivery model. Detailed maturity model and detailed implementation approach are out of scope for this chapter.

Capacity Planning Process Maturity Model

Most companies, small or large, benefit from performing all five levels of planning as each level has a distinct objective and associated decisions. The following diagram shows the capacity planning maturity model.

Figure 6. Capacity planning maturity model
Many job shops or small companies perform only basic capacity planning that focuses on planning for a week’s work or plan a job. These companies, which perform only ad hoc capacity planning, will fall at Level 1 or novice maturity.

All medium and large companies are at least at the level-two maturity level, which includes strategic capacity planning, annual budget planning, and detailed production planning because all three processes are part of the basic planning process; however, level of maturity and process efficiency among companies varies widely, which requires a separate discussion. Each subsequent maturity level adds an additional level of capacity planning. At maturity level five, boundaries among the last three levels start disappearing. Additionally, level five requires a sophisticated system that can run RCCP, CRP, and detailed planning in a single model with different aggregation and disaggregation logic catering to the needs of different levels.

Implementation

To implement an effective capacity planning process, the first step is to understand the planning organization’s current process maturity level, solution capabilities, and nature of the business. After that, evaluate the current capabilities with the desired capabilities to identify the gaps to fill. Following the gap identification, create a roadmap to bridge the gaps in phases—attain one maturity level and move to another.

As previously discussed, the capacity planning process relies heavily on data—the right process but the incorrect data will lead to a failure; lack of trust in results will cause a relapse into silo processes and broken links in the top-down process. A data assessment prior to implementation will provide insight into data quality and data gaps. For example, assess product, customer, and location hierarchies to understand if hierarchies are consistently maintained across product lines and business units. Additionally, assess if the same hierarchies and hierarchy levels are used across functional areas, such as finance, sales, marketing, demand planning, supply planning, etc. If differences exist, consider harmonizing hierarchies to bring all groups to use one hierarchy.

In large implementations, running a pilot program always pays off down the line. A pilot program allows the implementation team to establish and test the new processes with a business unit and a selected product type to identify the challenges at a smaller, manageable level and resolve them before rolling out the process to the broader organization. After a successful pilot, the organization can begin adding products and regions to the program.

CONCLUSION

While most medium and large companies run some capacity planning process, companies need to give capacity planning processes a holistic view—implementing five levels in the capacity planning process—looking from the strategic level at corporate headquarters to detailed daily-level scheduling at factories while integrating other groups in the levels in between. Additionally, digitalization of the supply chain has bestowed powerful capabilities, such as Artificial Intelligence and Machine Learning in planning tools and control towers enabling organizations to run self-healing processes with reduced human intervention.
Transforming the organization to build a robust capacity planning process is a long journey and the organization can begin the journey by first enabling the fundamental processes to support higher maturity in the future. A five-level capacity planning maturity model assists organizations in setting up those basic processes and helps ensure that a foundation has been established before moving to the next level. A robust multilevel capacity planning process prepares the organization to control the supply chain and respond to uncertainty in the new digital age.

**ADDITIONAL READING**


Contact us

Amit Gupta
Manager
Procurement & Operations Advisory
480-459-3830
agupta5@kpmg.com

www.kpmg.com