Synchronized Production and Inventories

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About the Author

Michael McClellan has over 30 years of experience serving and managing manufacturing enterprises. He has held a number of positions in general management, marketing and engineering, including President and CEO for a multi-division equipment systems supplier. In 1984 he and a group of associates founded Integrated Production Systems, a company that pioneered the use of computer systems to manage and track production events on the plant floor. His first book, *Applying Manufacturing Execution Systems*, defines manufacturing execution systems and explains the reasoning and history behind them. He is a frequent speaker at companies and manufacturing conferences, has presented a number of papers on plant information systems, and holds one patent. He has recently completed a new book, *Collaborative Manufacturing: Using Real-time Information to Support the Supply Chain*.

He currently lives in Washington state and is President of Collaboration Synergies Inc., an advisory company providing consulting services in the area of collaborative manufacturing system development and implementation, plant floor information systems and manufacturing execution systems.
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Collaboration in this instance has the specific purpose of synchronizing inventories across supply chain network partners. The objective is to substantially reduce or eliminate excess inventory by producing to actual current demand and by synchronizing with supply chain network partners on the demand and supply side, one common schedule with visibility for each participant.

Cost reduction opportunities are enormous. In the pharmaceutical industry supply chain, beginning with the retail drug store outlet to the distributor to the manufacturer to their suppliers and their suppliers, the inventory can be as high as 100 days of supply. In the electronics industry where the supply chain has at least as many layers, it is said the inventory can exceed one year’s supply, a particularly significant issue in an industry where products can become obsolete overnight. This inventory has many reasons for its existence. Some reasons are valid and some are questionable. A full examination within the context of the broad view of the value chain will bring a new perspective with potentially impressive cost reduction opportunities.

In his 1961 book, *Industrial Dynamics*, Jay W. Forrester recaps his study of the process of information feedback characteristics within companies and within supply chains. His study led to the conclusion that an increased demand level at the final customer causes an amplified demand wave when it reaches the manufacturer level. This is known as the Forrester Effect or Demand Amplification. Mr. Forrester identified these as the main causes:

- There was no demand visibility along the network. Responding to current information or demand changes was not possible.
- Information distortion was constant with participants affecting the process with their own interpretation of events and data.
- Intentional adjustments made by one party had compounding effects at other nodes of the supply chain.

One of the major factors effecting inventory overbuild is the distortion of demand information as identified by Forrester. One of these distortions is called the bullwhip effect; it describes the demand amplification primarily due to misinformation as requirements move up the supply chain. Demand distortion is generally used to describe an overreaction to actual demand but it could equally describe an under-response. The under-reaction would have adverse effects in that customer service could suffer and sales likely would be lost. Over responding or amplifying the demand information results in peaks and valleys in manufacturing causing problems of cost and inventory buildup.

In a paper, Dr. Hau Lee and his associates at Stanford University describe the bullwhip phenomenon in terms of causes and possible actions to mitigate its effects.

Dr. Lee identifies four major causes of the bullwhip effect:

**Demand Forecast Updating**—Every company prepares forecasts to guide their organization on subjects including production quantities, inventory levels, material requirements, and financial requirements. Because people are using available information when making or adjusting forecasts, they tend to react to obvious demand information. When a customer places an order with a supplier, the individual receiving the order is likely to see that as an indication of future demand. Forecasts are based on historical and the latest current information with individuals likely to overreact to positive trends by increasing their orders to upstream suppliers to ensure their ability to deliver. In a supply chain of any size the cascading effect of the distorted demand can be very significant.

**Order Batching**—Ordering cycles can distort demand by accumulating quantities into infrequently placed orders. An example is a company that sells one of an item each day but places orders every two months because of internal reasons. The supplier sees something quite different from the actual demand of one per day.

**Price Fluctuation**—Special pricing such as promotions or seasonality can cause customers to overbuy to meet future needs resulting in inventory that exceeds current demand.

**Rationing and Shortage Gaming**—A shortage, real or imagined, can be seen as a threat to future supply causing buyers to overbuy today to ensure inventory availability tomorrow.
Suggested responses to the bullwhip include:

Avoid Multiple Demand Forecasts—Base forecast information on a single schedule available to members across the value chain.

Break Order Batches—Collaborate with value chain partners to devise rules for order batching that provide smoothing of demand.

Stabilize Prices—Review internal pricing programs to avoid forward buying.

Eliminate Gaming in Shortage Situations—During shortages it might be an improvement to allocate products based on historical sales records. Sharing actual inventory and production information can also alleviate customer concerns.

Dr. Lee contends that the bullwhip effect is the result of rational decision making by members of the supply chain. By understanding the underlying issues companies can reduce the effects through more effective information systems and more collaborative relationships with supply chain partners.

Another aspect of the Forrester effect exists within companies as plants, departments, and individuals accumulate amplified inventory produced to counteract adverse events within the production processes. Usually referred to as buffer inventories they can exist anywhere in the supply chain production process. Some production systems have automatic built-in buffers in areas such as lot sizing or scheduling algorithms. Other systems can be affected by individuals at decision points by under or over reacting to real demand as in this example. An order is received for 100 widgets from a customer expected to order 50 per month. Believing this to be the new business level the annual forecast is revised upward. A check of on-hand inventory finds 30 in stock. The manufacturing economic order quantity has been set at 200, so production is scheduled for 200 units. Yield has been trending downward on the last three production runs to 90%. To offset the yield problem, production planning sets the quantity at 215. Purchasing uses the initial order quantity to order sets of purchased material for 200 widgets and then revises the order upward when production planning revises the quantity to 215. This is not a problem for suppliers except for the two vendors that made separate shipments, one for the original order and another for the addition. As the production order makes its way through the plant the yield is up, reaching 95%, but one of the separated vendor shipments is lost leaving 15 unfinished pieces currently stored on the floor at the final assembly station waiting for the remaining components to be found and assembled.

As a result of many decisions we now have an inventory that is not synchronized with demand.

Collaboration is used to address the fundamental causes of what are obviously dysfunctional system processes by first giving visibility to the processes and events on a holistic basis. It is not enough to view just a department or a plant, but each decision point of the entire value chain must be included in the examination of existing methods. The solution will include most of these steps.

Synchronization of Demand and Supply: This requires the participants to see the actual demand requirements with the value chain host providing leadership on demand identification for all value chain participants and processes. Decision points must be highly visible with absolutely correct real-time information and a single schedule.

On-line Information Transfer: Communications channels must provide timely and accurate transmittal of compliance as well as condition change information such as quantity revisions or exceptions to planned events. Modern information technology including Internet access, email, and automatic integrated system updates are required.

Time Buffers: Time buffers should be the tool used to respond to unanticipated events, not inventory buffers.

An excellent example of synchronized production has been accomplished by Ericsson Radio Systems, a manufacturer of cellular base stations for telephone companies. Over two years they envisioned, developed, and implemented a system linking 5 plants that includes multiple level suppliers across the supply chain. Today all customer requirements are open to the supply chain partners. All resources are available for review and on-line commitment allowing an account manager to provide a delivery confirmation response within 10 seconds, down from 24 hours. An order received by Ericsson is transmitted immediately to the supply chain partners providing a true pull environment. A graphic schedule is used to transmit the demand requirement to each partner. The systems include linked ERP, Supply Chain Event monitoring, and real-time information transmittal and availability down to the machine level and warehouse management system.
Synchronized inventory is a vast opportunity for business improvement. The auto industry wants to reduce the pipeline from thirty days to five. The electronics industry with one year of inventory supply is ripe for improvement made even more necessary by the quick product obsolescence. Reducing the hundred day pharmaceutical industry inventory would reduce costs, substantially affect warehouse and transportation costs, and could likely reduce the time from manufacture to customer use. There is probably no industry that could not benefit from synchronized production and those companies that improve their processes will have a tremendous advantage over their competition.

Collaboration between partners seems to be intuitively correct. People working together can usually accomplish more than people working against each other treating the other party as the adversary. If this is true for people it should apply to companies as well—but sometimes things are not as we might want to see them. Manufacturing collaboration does in fact have a great number of success stories to tell. The progress in product lifecycle management as companies use collaboration to reduce time to market and improve manufacturability seems widespread. The application of collaboration in retail industries has gotten excellent reviews and the CPFR® committee can cite a number of successful case histories. Analyst organizations are also very strong in their assessment of collaboration, its impact on companies that have applied collaboration, and the expected investment in applying collaborative methods.

But there are some issues to consider. In a study by John T. Mentzer, a professor of logistics at the University of Tennessee, and his associates James H. Foggin and Susan L Golicic, interviews were conducted with supply chain executives of 20 major companies to learn what experience has taught those who have applied collaboration ideas in their organizations. The study sought to gain insight on questions such as, “What exactly is collaboration and what enables it to take place? What are the obstacles and is achieving supply chain collaboration worth it?”

The study found that there were certain enablers required to achieve success.

- **Common interest and benefit sharing**—It is necessary for the collaborating parties to have a common interest and a win-win result from their efforts. The relationship must be based on a “what’s-in-it-for-us” perspective.
- **Openness**—Collaboration requires being open with information that may be considered proprietary. This does not mean full exposure of all company information, but it does require sharing information that allows each partner to see themselves as part of the team, not as an adversary.
- **Recognize who and what are important**—Not all partners and activities are equal. Choose those that provide the greatest benefits.
- **Cooperation and mutual help**—Collaboration is about teams that work together to achieve the common goal. Coercion and punishment are not effective methods to improve team relationships.
- **Clear expectations**—All parties need to know what is expected of them and others in the partnership.
- **Leadership**—Without someone to lead and guide the collaboration effort nothing significant will get accomplished.
- **Trust**—Trust must be evident throughout the organization at every management and functional level.
- **Technology**—Technology is not the panacea but it is essential to enabling a collaborative relationship across the supply chain.

There were a list of items the study found to be impediments to collaboration.

- **Doing things the old way**—Resistance to change continues to be a part of human nature even when there is a benefit.
- **Limited view of the supply chain**—It takes leadership to help individuals see the broader picture of the supply chain partnership or the extended enterprise.
- **Time investment**—Collaboration takes time and work. To get people to make the commitment they must truly understand the objectives and the benefits.
- **Inadequate communication**—When communication between partners is inadequate, the potential for problems increases exponentially.
• **Inconsistency**—Behavioral attitudes and operational executions must be consistent at all levels within the relationship.

• **Betrayal**—Lying, misleading, misrepresenting or anything else that is not a positive element of trust is the ultimate barrier to success.

• Other impediments include conventional accounting practices that focus too much on historical views of business cost allocations and annual supplier/customer negotiations that can be adversarial.

Some of the issues that were published in this study are repeated over and over in the available literature. A research project called Demand Activated Manufacturing Architecture Project (DAMA) was recently completed after a seven-year study effort. It was funded by the Department of Energy through the American Textile Partnership (AMTEX) to develop collaboration technology in the textile industry. They examined the full supply chain beginning with the fiber to the fabric provider to the garment manufacturer to the retailer to the consumer. The final report issued in September 2001 listed these issues as barriers to collaboration.

• Lack of trust is a major deterrent to collaboration. When companies do not trust each other, collaboration attempts fail. As a prerequisite, collaboration requires sharing more proprietary information than is currently shared. Only limited information is shared when there is lack of trust. Lack of trust was seen as critical issue between companies but also as an obstacle where there is lack of trust between divisions of the same company.

• Lack of trust in the ability of technology to provide adequate data.

• The inability of companies to identify what information should actually be shared.

• Failure of the collaboration champions to clearly demonstrate the benefits expected from collaboration to upper management.

• An inherent risk-adverse attitude within the company.

• Internal software to support collaboration is not in place within the companies wishing to participate.

• Companies are not currently organized to support collaboration—not enough resources.

After trust, the next major hurdle against collaboration appears to be culture. G. Hofstede, in the book Cultures and Organizations: Software of the Mind, defines culture as “the collective programming of the mind which distinguishes the members of one group or category of people from another.” Culture, for the most part, appears to be learned and shared through social interaction in our work and where we live. The important part is culture can have a direct effect on cooperation.

Collaboration, by design, brings people from different organizations together to work on common objectives. Each of the organizations in a collaborative partnership will have developed their own culture that is distinctive and unlikely to be easily modified. In some companies the culture allows people to arrive late but work well past the end of the normal workday. Some companies have a quiet soft-spoken demeanor where others may be loud and very forceful. Some may lean toward a very conservative position while others may be eager to push the boundaries.

Culture can be a barrier to cooperation and team building so it is important to recognize early on that attention must be paid to cultural issues and how this aspect of collaboration is to be managed. This should be a consideration in choosing collaboration partners and in staffing assignments. Organizational culture is not necessarily the Achilles heel of collaboration but it can be a serious issue if not adequately recognized for its possible impact.

The other side of the culture discussion are those instances where cultural diversity can be an advantage that allows the partnership to use the competencies and knowledge of each partner’s culture to foster improvement and benefit the overall partnership. This thought extends to the idea that the collaboration partnership is likely to form its own culture. Continuous learning and cultural evolution are hallmarks of a successful relationship as organizations coming from different organizations and cultures work together toward widening relationship objectives.
Culture was found to be an issue in the DAMA study. In 1997 the focus was changed from a technology driven approach to a business process approach that addressed these business requirements:

- The knowledge of the industry culture and business practices
- The development of maps of industry models of information flow
- The construction of collaborative frameworks for business practices
- The deployment of information systems to support the collaboration

After developing, simulating, and implementing a collaborative model that was built around the business requirements, the study reported these key findings.

1. A necessary ingredient for collaboration is an accepting culture. This may require modifying corporate value structures and activities to support collaborative relationships.

2. The primary target for a company must be the consumer or end user of the product—no matter where the company is in the supply chain.

3. There is an evolutionary path that companies follow as they move toward a true collaborative environment that takes them from a focus on internal processes and systems to a global view of the supply chain. The report suggested three distinct phases to develop a collaborative supply chain.

**Phase One -- The Preparation Phase** -- This phase encompasses cultural change and development of methods and processes. The report cited that a significant amount of preparation is required, particularly if a company is not ready for change. Included in this phase is the need to identify and address cultural barriers to be overcome. Once the cultural issues are being resolved, the next step is to ensure each partner's internal processes are in order to support collaboration.

**Phase Two -- The Piloting Phase** -- The best way to reduce risk is to first do a small-scale pilot. The piloting phase is manpower intensive as the team works to identify operational processes that fit each partner.

**Phase Three -- The Scaling Phase** -- The scaling phase is where the scope of the pilot is increased to include more products, more collaborative functions, and/or more participants.

The study outlined this ten-step preparation program that is essentially a gearing up process to determine if supply chain inventory synchronization has a place in your environment. The full outline of a collaboration process follows this preparation and pilot phase outline. This program follows the three-phase process indicated above.

1. **Select Trading Partners.**
   a. Identify all partners in a supply chain.
   b. Identify the products that will serve as the basis for collaboration.
   c. Obtain executive level commitment to participate.
   d. Secure a signed front end agreement from all partners, which includes but is not limited to:
      i. Statement of intellectual property
      ii. Data security
      iii. Confidentiality

2. **Select Collaboration Opportunities.**
   a. Investigating possible opportunities for collaboration may involve a very formal analysis of the supply chain or a very informal analysis that results from a discussion between trading partners.
   b. Selected trading partners choose opportunities to leverage through collaboration.
      i. Improve sales forecast.
      ii. Improve order forecasts.
      iii. Reduce lead times.
      iv. Reduce inventory levels.
      v. Increase visibility of information throughout the supply chain by bill-of-material explosion from the end product through the supply chain.
3. Identify information to be shared.
   a. Determine what information will be required to support collaboration for each product focus.
   b. Determine the information sharing format e.g.
      i. EDI transactions or other software system linkage
      ii. Excel spreadsheets
      iii. Memos

4. Select the method for collaboration.
   a. Identify the methods that will facilitate the collaboration.
      i. E-mail, faxes, mail
      ii. Conference calls, video conferences
      iii. Face to face meetings
      iv. On-line collaborative software linkage
   b. Identify the resources, including the computing resources (network connection, software installations, PC requirements, etc) required to support each method selected.
   c. Determine the time required to support each method that will be used and the frequency of collaboration.

5. Specify roles, responsibilities, and team members.
   a. Specify the team lead for each company.
   b. For each company, determine the business role and function that can supply the appropriate information and support for successful collaboration.
   c. Determine and outline the responsibilities for each of the identified roles.
   d. Identify the individuals who are responsible for the corresponding roles.
   e. Specify the estimated time commitments for each individual in their role.

   a. Identify quantifiable measurements that will be used to determine if the collaboration was successful.
   b. Ensure that the collected information will support the defined measurements including benchmark data.
   c. Determine who will be responsible for collecting and analyzing data.
   d. Use metrics as an improvement to the collaborative process, rather than letting metrics drive the process.

   a. Study business practices required and develop business process activities and information flows to accomplish the collaboration opportunities.
   b. Develop a new business process model to define this activity. The process model will identify specific work practice changes.
      i. Identify areas in the business that will require change to support collaboration.
      ii. Determine if the current business practices will allow the change required.
      iii. Identify alternate practices the business will support for collaboration.
      iv. Business process examples:
         1. EDI forecast transactions will be integrated into the planning software and made available to all supply chain members at the same time.
         2. Purchase orders commitments for the pilot will be submitted through EDI transactions that are derived through the collaborative process.

8. Develop a timeline for collaboration.
   a. Specify collaboration start and completion dates.
   b. Identify and schedule training sessions to be conducted.
   c. Schedule meetings.
   d. Specify milestones.
   e. Include the frequency of collaboration.
9. Agree on a reporting process.
   a. Specify a reporting template.
   b. Determine contents to be included.
      i. Company names
      ii. Pilot objectives
      iii. Methods and technology used
      iv. Measurements for success
      v. Resources involved
      vi. Business practices and processes implemented
      vii. Summary of pilot effectiveness
      viii. Benefits realized
      ix. Trading partner relationship changes
      x. Recommended changes
   c. Determine who the report recipients will be.
   d. Determine a timeline for reporting.
10. Implement the collaborative process.
    a. Implement methods and technologies.
    b. Collect data.
    c. Analyze data.
    d. Review processes.
    e. Review business processes.
    f. Implement change as required.

The first nine steps are included in the preparation phase and help define the steps necessary to implement a successful pilot. Step ten is included in the piloting and scaling phase.

Once the decision to collaborate has been reached, the DAMA model outlines these activities.

• **Develop Business Planning Agreements.** It is necessary that each trading partner begin by developing a business planning agreement. Each company must assess their own strategy and goals to ensure that these are incorporated into the partnership agreement. The goal is to arrive at a win-win situation for all players. This requires sharing some risk and rewards, in addition to sharing common goals.

• **Populate the Supply Chain Utility.** In this activity the trading partners populate a supply chain utility that is envisioned to be a collaborative software system that should support product definition; supply chain planning; supply chain visibility; and secure data sharing. The initial population would require each trading partner to provide initial information in the following areas:
  • Manufacturing information including lead times, process times and transport times
  • Capacity that has been allocated to the partnership
  • Manufacturing information including bills-of-material, product specifications and boundary constraints
  • Exception criteria
  • Assistance in establishing an ontology, or common vocabulary
  • Define the Products. Collaboratively defining products in a supply chain requires increased supply chain visibility of all partners to the product lines in each sector (fiber, fabric, apparel, retail). The process begins with market research about customer demand. The partnership collaborates to develop products to meet demand. Once the product is developed, a product definition is provided to each member in the chain.

• **Collaborate on Exceptions for Product Definition.** If a particular product attribute is not available an exception is generated. Resolution and/or collaboration of the exception may involve phone calls, email, or on-line interaction. Resolution may require adding a product or manufacturing capability by changing the product mix or outsourcing to a third party supplier who is not a member of the collaborative partnership.
• **Forecast and Plan Capacity Commitments.** One or several partners in the supply chain may develop the forecast. Once the forecast is developed it is made visible to all members through the Supply Chain Utility. Each forecast must be reflective of the portion of the order that will be filled by the next member in the supply chain. The initial loading of the Supply Chain utility will ensure that the correct proportions for an order are maintained. Based on the forecast received, each manufacturing member of the partnership should then provide a capacity commitment to the forecast for the specific product line.

• **Collaborate on Forecast or Capacity to Meet Forecast Exceptions.** A forecast may exceed original capacity commitments or fall short of the commitments. When this exception occurs, the affected partners must collaborate and either find additional capacity from an increase in demand or share associated risk of a reduction in forecasts. The partnership agreement should provide guidelines for handling these exceptions.

• **Schedule Production and Product Delivery.** The Supply Chain Utility will balance a final order commitment against initial capacity commitments. Using that information, in addition to manufacturing capability data, the utility will generate work orders for each manufacturer in the supply chain. Each manufacturer then processes these work orders individually.

• **Collaborate on Product Ship Date Exceptions.** Resolving and/or collaborating on product ship date exceptions leads directly into the expedite production and delivery step. A late ship date on fiber could impact all members along the supply chain. But the textile manufacturer might have yarn in inventory that was not previously entered into the supply chain utility. The supply chain utility processes the updated data for exceptions.

• **Expedite Production and Delivery.** Manufacturers’ ship dates generated from the process of collaboratively scheduling production will be compared to delivery status provided by each manufacturer on a regular basis. If ship dates and delivery status for product are not meeting the agreed upon product ship dates, an exception will occur. Most exceptions will be made available to the trading partner who is initially impacted by the exception, usually the next downstream partner.

• **Execute Delivery.** The carrier handles the execution of delivery and provides delivery status information. The supply chain utility determines if the target ship dates are being met.

The DAMA project was a study to determine how and what to do in the textile industry supply chain to reduce the inventory pipeline. The study work began long before supply chain management software and the Internet became part of our vocabulary. There was some effort to commercialize the ideas and system software as the study reached certain milestones, but there was little interest from systems providers to exploit the technology at the time.

The following quote by Michael Hammer, former Professor of Computer Science at Massachusetts Institute of Technology, now President of Hammer and Company, is offered as an end to the discussion on the subject of culture. It is taken from the final report on the DAMA Project and is in response to a question regarding trust and companies working together.

"Companies often look at themselves as sort of a self-contained medieval enterprise, a city state if you like. Everybody else around them is their enemy. In fact, many companies operate as though their customers were their number one enemy, their suppliers their number two enemies, and other departments inside their company are their number three enemies."

The processes that have been outlined in the DAMA model are oriented to consumer goods sold through retail systems. In other industries such as electronics or industrial equipment, where the consumer is not so easily defined, demand generation uses different sources of input. Although the DAMA outline is an excellent starting point, each initiative should be examined to include other industry specific steps that might modify the process.
References