IEMS Vol. 7, No. 1, pp. 57-65, June 2008.

# Order Promising Rolling Planning with ATP/CTP Reallocation Mechanism

**Juin-Han Chen**
Department of Industrial Engineering and Management, Cheng Shiu University
840, Cheng-Ching Road, Niausung Shing, Kaushiung County, Taiwan 833, Republic of China
Tel: +886-7-7310606 ext.3515, Fax: +886-7-7315367, E-mail: jchenjh@gmail.com

**James T. Lin†**
Department of Industrial Engineering and Engineering Management, National Tsing-Hua University
101, Section 2 Kuang Fu Road, Hsinchu, Taiwan 300, Republic of China
Tel: +886-3-5742650, Fax: +886-3-5722685, E-mail: jtline@ie.nthu.edu.tw

**Yi-Sheng Wu**
Department of Industrial Engineering and Management, Yung-Ta Institute of Technology and Commerce
No. 316, Chung-Shan Rd., Lin-Lo, Pingtung County, Taiwan 909, Republic of China
Tel: +886-8-7233733 ext.221, Fax: +886-8-7228046, E-mail: yswu@mail.ytit.edu.tw

Selected paper from APIEMS2005

**Abstract.** Available-to-promise (ATP) exhibiting availability of manufacturing resources can be used to support customer order promising. Recently, one advanced function called Capable-to-promise (CTP) is provided by several modern APS (advanced planning system) that checks available capacity for placing new production orders or increasing already scheduled production orders. At the customer enquiry stage while considering the order delivery date and quantity to quote, both ATP and CTP are allocated to support order promising. In particular, current trends of mass customization and multi-side production chain derive several new constraints that should be considered when ATP/CTP allocation planning for order promising - such as customer's preference plants or material vendors, material compatibility, etc. Moreover, ATP/CTP allocation planning would be executed over a rolling time horizon. To utilize capacity and material manufacturing resource flexibly and fulfill more customer orders, ATP/CTP rolling planning should possess resource reallocation mechanism under the constraints of order quantities and delivery dates for all previous order promising. Therefore, to enhance order promising with reliability and flexibility to reallocate manufacturing resource, the ATP/CTP reallocation planning mechanism is needed in order to reallocate material and capacity resource for fulfilling all previous promised and new customer orders beneficially with considering new derived material and capacity constraints.

**Keywords:** Available-to-Promise (ATP), Capable-to-Promise (CTP), Order Promising, Rolling Planning, Reallocation Planning

## 1. INTRODUCTION

### 1.1 The Role of Order Promising Planning

Currently, customers may order for finial products to manufacture in one country and consign the appropriate or preferential materials from another country, and then ask the logistics service parties (LSP) to ship their finial products to yet another country. In this global supply chain environment, business models and information technologies are gradually changing to adapt to the supply chain operations.

Advanced Manufacturing Research (AMR) referred to the fact that besides the advanced computer technology, many manufacturers employ advanced planning and scheduling (APS) solutions with new planning and scheduling techniques that consider a wide range of constraints, such as material availability, machine and labour capacity, customer service level requirements, etc., to produce an optimized plan (Bermudez, 1998). Furthermore, Gunther (2004) proposed the functional modules of APS to support supply chain planning that include strategic network design, supply network planning, demand

† : Corresponding Author

planning, external procurement, production planning or detailed scheduling, transportation planning or vehicle scheduling, order fulfillment and ATP/CTP. In which, CTP is called capable-to-promise that is an enhancement functionality provided by recent modern APS for placing new production orders or increasing already scheduled production orders. The order fulfilment and ATP/CTP module is to match customer orders against available quantities on stock and from scheduled receipts. And then, customer requests for product delivery of quantity, time and location can be answered.

Rudberg and Wikner (2004) exhibited that this trend of mass customisation results in the customer order decoupling point (CODP) shifts upstream. As Figure 1 indicated, CODP is the interface between forecast-driven and order-driven planning processes that an upstream CODP such as assemble-to-order (ATO) or make-to-order (MTO) involves rather long order lead-time (Fleischmann and Meyr, 2003). Different customers would generally have different specifications, however, the same products may be ordered by the same customers repeatedly (Yeh, 2000). A client, distinct from end user consumption behaviour, has to wait for the delivery of ordered products, but at the very least wants to get a reliable promise that he can receive the product in the promised quantity at the promised date. Therefore, order promising process is very important within such a competitive supply chain environment to build core-competence through fast and reliable order promises in order to retain customers and increase market share.

### 1.2 The unsatisfactory of traditional order promising mechanism

According to APICS (American Production and Inventory Control Society) dictionary ($9^{th}$ edition), ATP is the uncommitted portion of a company's inventory and planned production maintained in the master schedule to support customer order promising. Kilger and Schneeweiss (2005) indicated that the assumptions of this traditional order promising mechanism, infinite capacity of manufacturers and suppliers and fixed lead-time of production and purchase, result in unfeasible order promising and decreasing the delivery performance.

Moreover, traditional approach for order promising is just adapted to make-to-stock (MTS) model that ATP exhibiting availability of finished goods are used to sup-

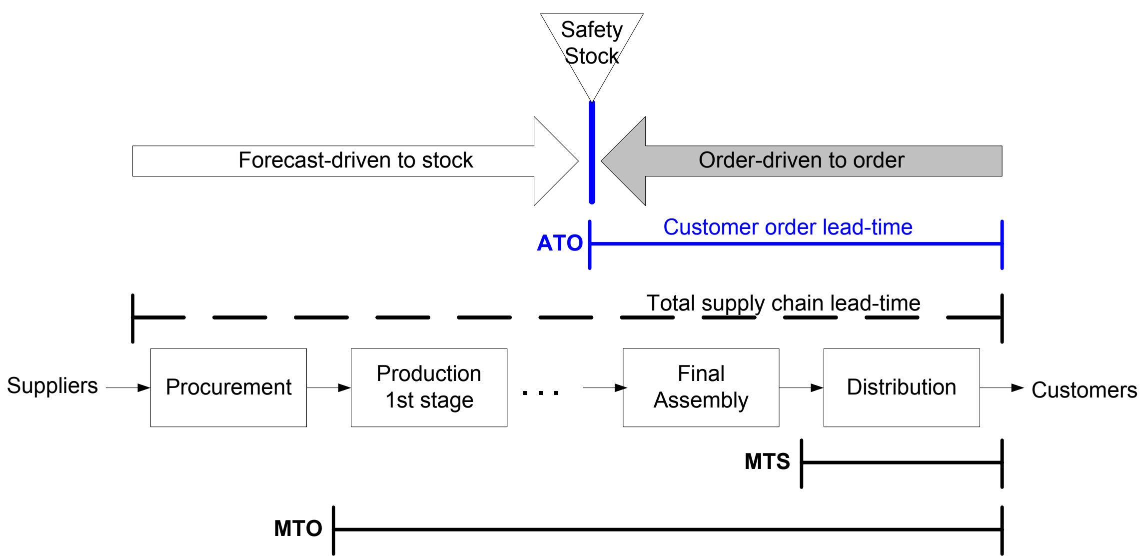


**Figure 1.** CODP and customer order lead-time in MTS/ATO/MTO

**Table 1.** Major limitations / restrictions and ATP granularity for demand fulfillment as adapted from Kilger and Schneeweiss (2005)

| Production Model | Order Lead-time | Bottleneck/Restriction | ATP Granularity |
|---|---|---|---|
| MTS | Transportation time | Available stocks of finished goods | Finished goods |
| ATO | Assembly time + Transportation time | Available stocks of components and capacity of the assembly process | Components; Assembly capacity |
| MTO | Production time + Transportation time | Available stocks of components and capacity of the production process | Components; Production capacity |

port customer order promising on first-come-first-served policy that all orders are treated the same. The order promising planning of the ATO or MTO model is different from the MTS model. In the MTS model, the major bottleneck for demand fulfilment is the available stocks of finished goods. In the ATO or MTO model (see Table 1), the manufacturing resources such as materials and capacity after CODP should be checked and allocated for order promising (Kilger and Schneeweiss, 2005). Besides, constraints derived from mass customisation such as customer-preference plants or material vendors, material compatibility, etc., should be considered when allocating these resources.

Furthermore, customer demand can be segmented and prioritized according to product profit, sales growth potential or customer relationship, etc. The higher profit but late arrival customers may need the same manufacturing resources as the lower profit but early arrival customers. Taking TFT-LCD industry as illustration, the charge for LCD-TV is obviously higher than LCD monitor although they need the same manufacturing capacity. To take into account the company profit and customer relationship, orders cannot be still promised by traditional approach with a first-come-first-served policy. Therefore, to maximize revenue from higher profit products or to maintain customer relationships with important customers, there is a need to develop order promising rolling planning process with ATP/CTP reallocation mechanism that can reserve resources for late-arriving but high-margin or high priority demand.

### 1.3 Research Objective

Accordingly, to build core-competence for company through giving customers more reliable order promises and through enhancing manufacturing resources utilization for high-margin or high-priority demand, this paper proposes a two-phase order promising process in which resources are reserved first according to some priority rule in phase 1. And then, employing optimal methodology, mixed integer linear programming (MILP), in phase 2, available resources are allocated to customer orders considering constraints derived from mass customization for reliable order promises.

TFT-LCD industry consist three main processes, Array, Cell and Module processes (see Figure 2). The capacities of Array and Cell processes are expensive and thus should be utilized as more as possible. Therefore, Array and Cell processes are forecast driven to build LCD panel stocks. On the other hand, the final Module process is to assemble LCD panel with IC, PCB and backlight that affecting the performances of display should be recognized by customers. Consequently, Module process is order driven to fulfill customer requirements. The production model of TFT-LCD industry is ATO but not MTS and possesses the characteristics of mass customization. The customers are system application manufacturers such as notebooks, LCD monitors or LCD TVs, etc. These customers are as client relationship with TFT-LCD industry that they request their product specification requirements and then TFT-LCD manufacturers should respond if these requirements can be fulfilled. Thus, one TFT-LCD manufacturing is taken as illustration for demonstrating the significance of the proposed order promising rolling planning process with ATP/CTP reallocation mechanism.

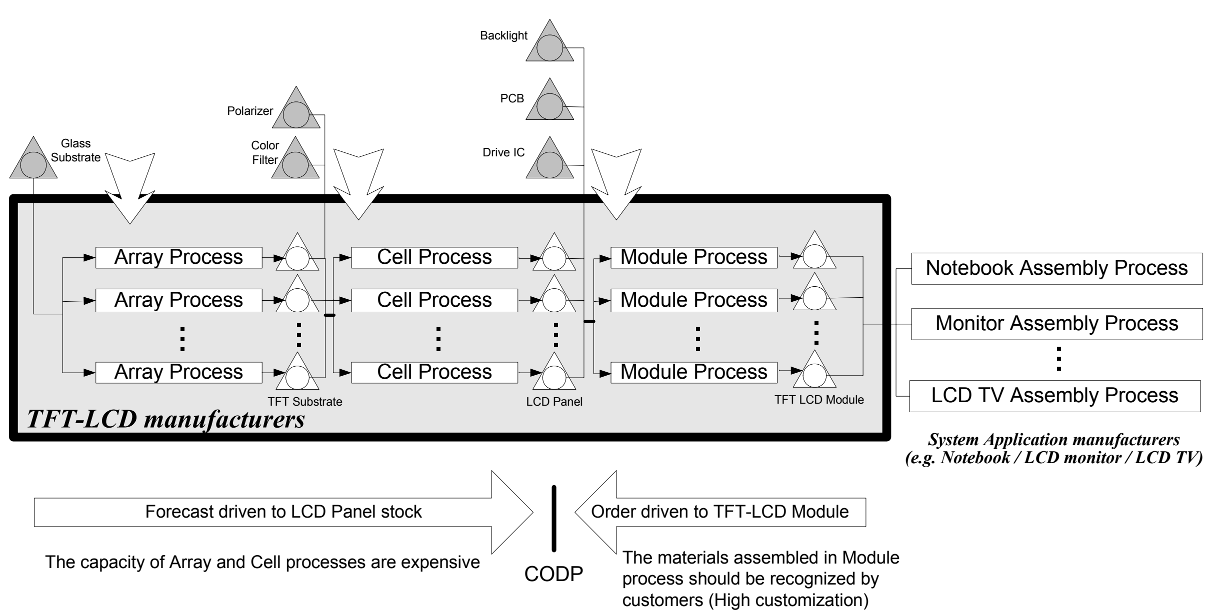


**Figure 2.** TFT-LCD manufacturing process

## 2. LITERATURE REVIEW

### 2.1 Order Promising From Master Production Schedule

On time delivery is usually used as a key performance indicator for the quality of order promises. Reliable order quotes must be based on feasible supply plan. Ware and Fogarty presented that ATP is frequently calculated from the master scheduling process for promising delivery to customers and the accurate information of this quantity is key to customer service (Ware and Fogarty 1990). Moreover, the different master scheduling methods used to promise customer orders will result in different delivery lead-time performance and percentage of promises kept (King and Benton 1988, McClelland 1988).

Utilizing experimental design approach to study the appropriate master scheduling methods in MTO environment, McClelland (1988) showed that using master production schedule (MPS) to establish customer promise dates increases the percentage of promises kept and the master scheduling methods that can monitor capacity allocations and material requirements achieve a higher percentage of promises kept than that without considering capacity requirements or material availability.

Besides, in APS functional modules, master planning creates a plan for the complete supply chain such as purchasing, production, distribution, etc. Kilger and Schneeweiss (2005) also pointed out that synchronization of the supply processes and order promising based on the master plan improve the on time delivery.

### 2.2 Material and Capacity Allocation For Order Promising

With regard to material allocation for order promising, Bertrand *et al*. (2000) developed a hierarchical pseudo bills of material for efficient checking material availability. Allocating materials to customer orders during customer order acceptance in ATO environment that product families often with many options and features are offered to the market. To handle the complex BOM structure and the diverse characteristics of components, Xiong *et al*. (2003a) proposed a concept of dynamic BOM to take into consideration the material availability for all components easily when compute ATP. Moreover, to compute ATP in a timely and efficient manner, Xiong *et al*. (2003b) proposed a Web-based flexible available-to-promise computation system to help manufacturers understand their capability for fulfilling customer orders in terms of material availability in today's e-business environment.

With regard to capacity allocation for order promising, Taylor and Plenert (1999) proposed a forward and backward procedure to identify capacity available-to-promise (CATP), the amount of unused machine capacity and slack machine time, for establishing realistic order promising dates. Based on this forward and backward procedure, Jeong *et al*. (2002) developed an ATP system for TFT-LCD industry in global supply chain environment and an efficient heuristic for scheduling TFT LCD module assembly process for effectively using the unused capacity at shop floor level. Jung *et al*. (2003) proposed an optimized ATP system for MTO supply chain environment that calculates and allocates available capacity for giving customers delivery date promise. Besides, Guerrero (1991) studied how to allocate and consume capacity in the final assembly schedule (FAS) and MPS for ATO environment in order to maintain high order fill rates and consume capacity in an efficient manner. His research showed that different capacity allocation strategies such as 'early allocation', allocating to the most current part of capacity and move progressively to future periods as available capacity is exhausted, has moderate effect on order fill rates and capacity utilization. Recently, Lin and Chen (2005) proposed one order promising mechanism with ATP allocation planning considering material and capacity constraints after CODP to fulfil the requests from customers, such as customer's preference materials or specifications.

### 2.3 Order Promising Planning Methodology

Pibernik (2005) indicated that advanced available-to-promise comprises of an assortment of methods and tools to enhance order promising and he proposed a theoretical framework of models and algorithms for order quantity and due date quoting. He used three characteristics -- availability level, operating mode, and interaction with manufacturing resource planning -- to classify order promising planning methods.

Chen *et al*. (2001) proposed a quantity and due date quoting ATP mechanism with mixed integer programming (MIP) model that allows customized configurations and takes into account a variety of realistic supply chain constraints, such as material compatibility, material substitution preferences, and capacity utilization. Moreover, Chen *et al*. (2002) used simulation experiments to investigate the sensitivity of supply chain performance to changes in certain parameters, such as batching interval size for collecting orders and customer order flexibility for product configuration. Besides, Ozdamar and Yazgac (1997) proposed a capacity driven planning system using a binary linear programming (BLP) model for order due date setting in MTO production systems.

### 2.4 Revenue Management and Seat Reservation

The trend of segmentation and prioritization of customer demand drives many studies introducing revenue management approach for order booking in ATO or MTO environment. Revenue management is an order acceptance and refusal process that integrates the marketing, financial, and operations functions to maximize revenue from pre-existing capacity. Harris and Pinder (1995) indicated that many of revenue management environment characteristics are also found in ATO operations such as perishable resource, fixed capacity, high capacity change costs, demand segmentation, advance sales/bookings, stochastic demand, and historical sales data and forecasting capability.

Moreover, Tamura and Fujita (1995) adopted seat reservation concept to propose a new production planning and scheduling system, customer oriented production planning system (COPPS), in which production seats are first created based on forecasted demand, and then orders received are assigned to the seats. The major advantage of COPPS is its ability to efficiently respond to customer inquiries, such as whether the required due date can be achieved.

## 3. TWO-PHASE ORDER PROMISING ROLLING PLANNING PROCESS

As previous indicated, ATP of finished goods calculating from MPS for order promising is just adapted in MTS model and the priority of all orders are treated the same. This mechanism is insufficient for the current demand of segmentation and prioritization and ATO/MTO production model that material and capacity resources should be checked and allocated after CODP. Besides, high flexibility of product configurations and multi-side production chain result in the difficulty of order promising that derive constraints from customers assigning their preference material vendors and plants. Therefore, there is a need for one order promising rolling planning process with resource reservation mechanism to reserve manufacturing resources for important customers or higher profit products and considering critical material and capacity constraints from mass customization to provide reliable order promising responses.

This proposed order promising rolling planning process introduces revenue management and seat reservation concept to reserve resources in advance for higher profit products and important customers. Moreover, it is to increase the percentage of promises kept, based on feasible supply capability of MPS and FAS and material supply calendar to establish reliable promised delivery quantity and dates.

Thus, this research designs the two-phase order promising process as Figure 3. Phase I is for forecast reservation that can reserve resources in advance according to customer forecasted demand and some priority rule. Phase II is for order promising that is restricted on the reservation quantity from phase I, ATP of material and capacity are allocated for giving customers commitments of delivery dates and quantity.

Phase I includes the following three parts:

(1) First, according to customer forecasted demand and sales plan, sales department aggregate the netting forecasted demand. In which, the cus-

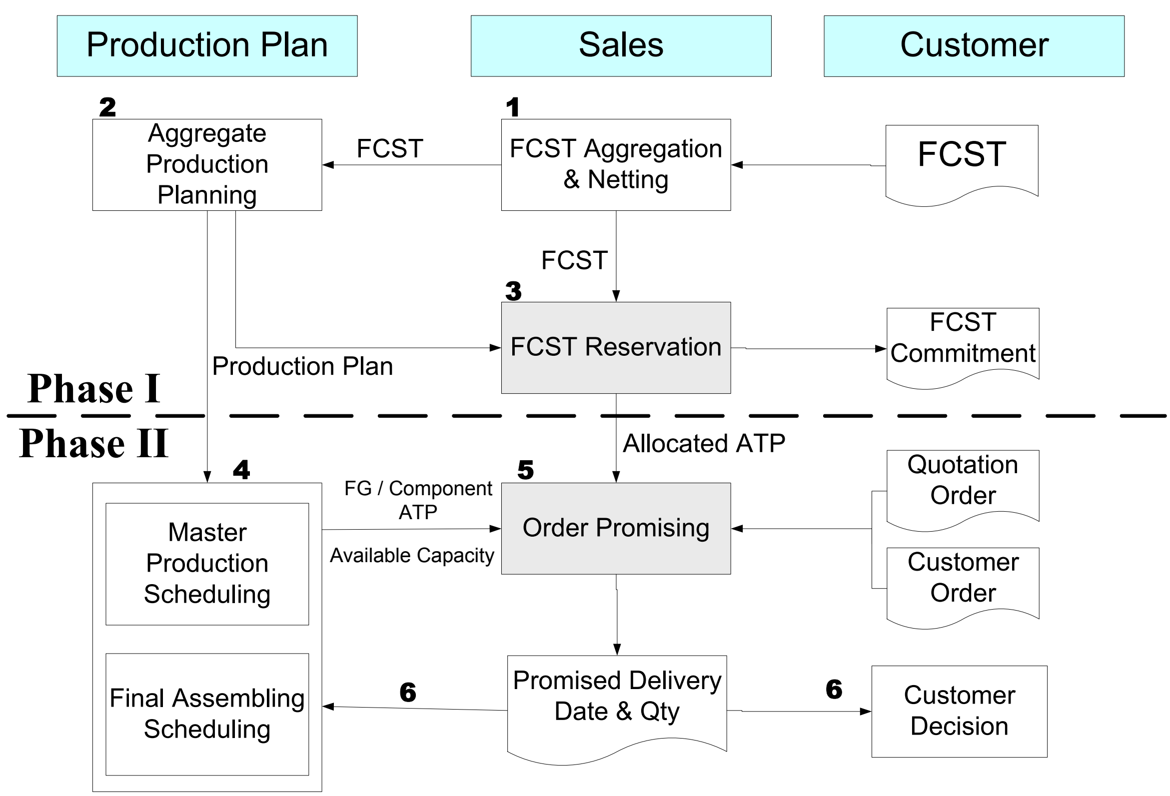


**Figure 3.** Two-Phase order promising procedure

tomer forecasted demand can be estimate from historical sales data, provided from customers with long term cooperative relationships, and adjusted with market trends.

(2) Then, in light of netting forecasted demand, production plan department takes the major bottleneck capacities and materials into account and then arrange the aggregation production plan (mostly in monthly time buckets).

(3) Following that, based on the netting demand forecasts (demand) and the aggregation production plan (supply), forecast reservation is planned by the sales department according to product profits or importance of customers.

ATP is represented in the same granularity as the supply given by the aggregation production plan and is maintained in discrete time buckets. The quantities that sales reserve from aggregation production plan for customers are called allocated ATP (AATP). The AATP are for reserving resources and giving forecast commitments to customers. Besides, the AATP are important referrals in phase II for order promising to prevent low-margin but early-arrival orders consume most manufacturing resources that high-margin but late-arrival orders cannot be fulfilled.

Phase II is performed for order promising including the following three parts:

(4) According to the generated aggregation production plan, MPS is concentrated on bottlenecks to calculate the production plan of each finished product under the objective of efficiently utilizing production capacities. In which, the time buckets of MPS is weekly or daily that is smaller than in aggregation production plan. Besides, based on the production plan of each finished product, the time-phased requirements and purchasing plan of critical materials can be calculated.

(5) When receiving the quotation orders from customers, available material and capacity resources with time-phased dimension after order penetration point are assigned for orders to calculate available quantity and feasible delivery date. This is for preventing the unreasonable assumptions of fixed lead-time and infinite capacity from traditional order promising mechanism. Not only finished goods ATP, both material and capacity ATP are considered to fit for ATO / MTO model. Moreover, this mechanism takes account of quotation order requirements such as order quantity and due date, customer preference material vendors and plants to provide customers acceptable products (see Figure 4). Besides, ATP should be allocated according to AATP in phase 1 that promised order quantity cannot be more than corresponding AATP to prevent manufacturing resources are consumed by early-arrival but low-margin or less important orders.

(6) Finally, the calculated available order delivery quantities and dates are responded to customers for getting their commitments. Moreover, the promised orders are entered into MPS for forecast consumption and into FAS to schedule the operations for completing the products of specific customer orders.

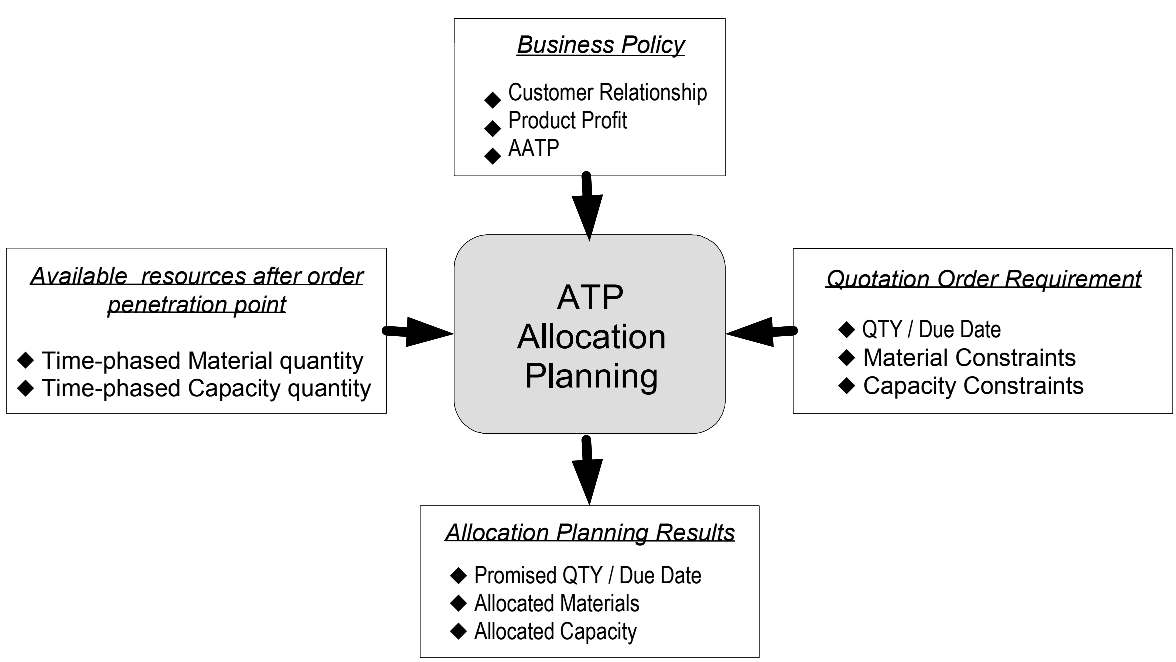


**Figure 4.** ATP allocation planning mechanism for order promising during phase II

## 4. TFT-LCD INDUSTRY AS ILLUSTRATION

The TFT-LCD industrial structure should be differentiated into three types, the upstream key components suppliers, the midstream TFT-LCD manufacturers and the downstream system application manufacturers, such as notebook, LCD monitor or LCD TV manufacturers (see Figure 2). The three main processes of making TFT-LCD are Array process, Cell process and Module process. For TFT-LCD manufacture plants, one plant comprises just one process and each process exists in many plants where it may possess different generations of process equipments. This derives the multi-site network structure of TFT-LCD manufacture plants. The same process in different plants may produce different products, like the Array process in one plant is for 15″ and 17″ panel sizes and in another plant it's for 19″ and 21″ panel sizes. In virtue of evaluating the production quality for different generations of process equipments and taking the transportation cost into account, some system application manufacturers may assign their preference production paths.

Figure 7 is the bill-of-material (BOM) of TFT-LCD module and these six main TFT-LCD key components, glass substrate, colour filter (CF), polarizer (PL), drive IC, PCB and backlight (BL) are fabricated or assembled in corresponding processes. Figure 8 shows the TFT-LCD product hierarchy and the characteristic according to the materials and manufacturing processes. For these six key components, there are several vendors for each key component and existing material compatibility problems, like the substrate of colour filter and glass substrate should be produced with consistent raw material. Moreover, some components, such as one drive IC, should consist with the

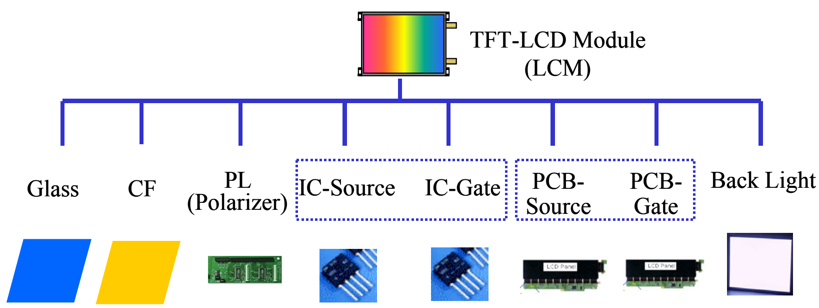


**Figure 7.** BOM of TFT-LCD module (LCM)

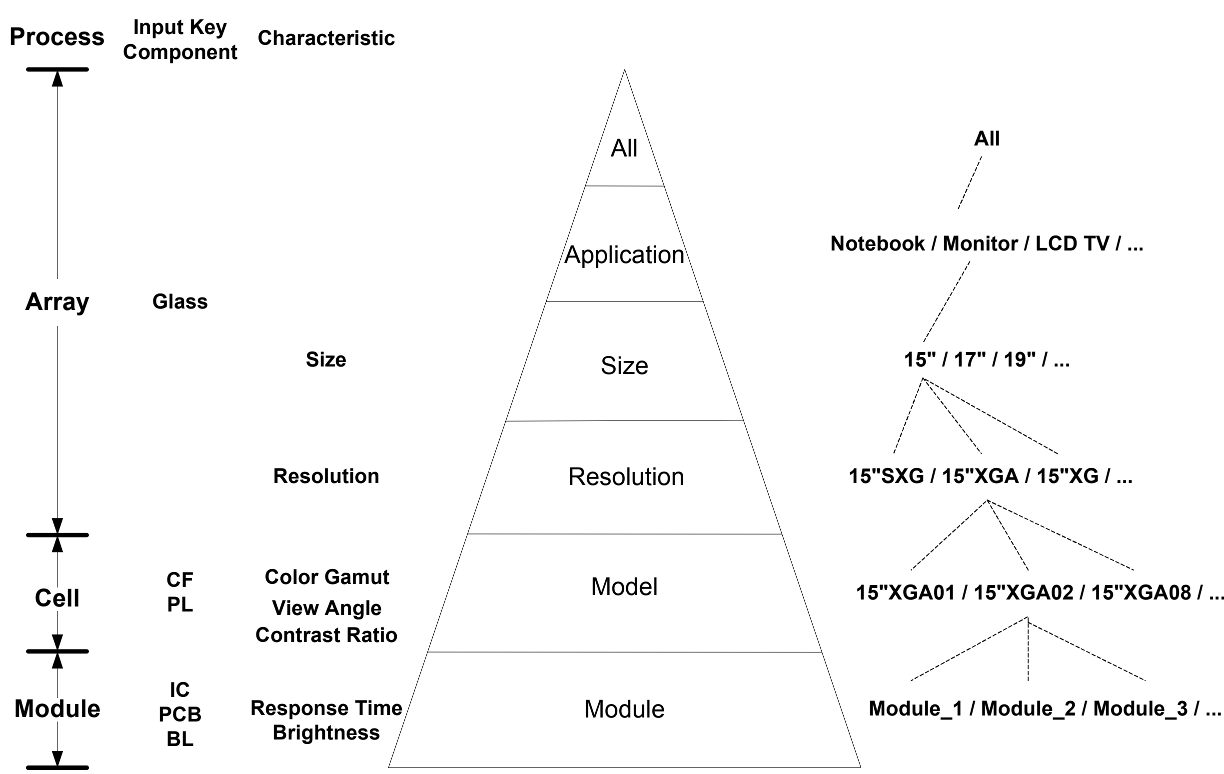


**Figure 8.** TFT-LCD product hierarchy

specifications of one TFT-LCD panel and PCB to perform high display quality. Therefore, most system application manufacturers may place orders with allocating their preference material combination modules for TFT-LCD panel, drive IC, PCB and BL. This high customisation derives the constraint of customer's preference material combination modules and drives TFT-LCD manufacturers taking ATO production model because Module process is the last stage of TFT-LCD manufacturing process, where TFT-LCD panel, BL, drive IC, and PCB are assembled.

The increasing global demand of notebooks, LCD monitors and LCD TVs thrive TFT-LCD industry. Recently, Taiwanese TFT-LCD makers shared almost half of the global market for TFT-LCD panels together. Because TFT-LCD industry grew up originally in Japan, the producing technologies of TFT-LCD, the TFT-LCD fabricating equipments, and the TFT-LCD key components are particularly controlled by them. The rapidly increasing global demand of TFT-LCD derives the deficiency of the TFT-LCD manufacturing resources such as key components and capacity. Therefore, TFT-LCD manufacturers have been confronted with the problem of how to fulfil customer demand by beneficially allocating the scarce TFT-LCD material and capacity manufacturing resources under the capacity and material constraints such as available material/capacity quantity, customer's preference production path and customer's preference material combination modules.

Consequently, this study takes one TFT-LCD industry to illustrate the importance of the proposed two-phase order promising rolling planning process considering critical material and capacity constraints after CODP, product profit and importance of customers to reserve manufacturing resources beneficially in advance phase 1 and then to provide more reliable customer order promises in phase 2.

## 5. CONCLUSION

Mass customization results in CODP shits upstream and involves rather long order lead-time that customers have to wait for the delivery of ordered products. So customers want to get a reliable promise that they can receive the product in the promised quantity at the promised date. Therefore, order promising process is very important within such competitive supply chain environment to build core-competence through fast and reliable order promises in order to retain customers and increase market share.

ATP calculating from MPS exhibit availability of finished goods to support customer order promising in MTS production model and all orders are treated the same on first-come-first-served policy. However, in global supply chain environment, customers may indent order to manufacturers and allocate their preference material combination modules or furthermore their preference production paths. This increasingly mass customization results in the insufficient of traditional order promising mechanism that cannot consider constraints from quotation order request such as customer's preference materials and capacity. Moreover, when the requirement volumes of customer demand are more than available manufacturing resources, manufacturers should beneficially allocate manufacture resources to products of higher profits or more important customers. Constraints from mass customization and demand segmentation result in the complex of order promising mechanism.

Therefore, this study designs a two-phase order promising rolling planning process to reserve capacity and material resource for important customers or higher profit products in advance phase I. And then restricted by the AATP in phase 1, phase II is for order promising planning according to feasible supply plan to give customers reliability due date and quantity. Besides, this study proposes order promising planning model that applies MILP approach to prioritize allocating manufacturing resource for high profit products or important customers in phase I and to consider material and capacity constraints after CODP in phase II. One TFT-LCD manufacturer is taken to illustrate the importance of the proposed two-phase order promising rolling planning process. To get reliable order promising response and more efficient ways of utilizing manufacturing resources, ATP/CTP reallocation planning mechanism with optimal methodology or efficient algorithms is necessary.

## REFERENCES


American Production and Inventory Control Society (APICS) (1998), *Dictionary*, Alexandria, VA, 9th ed.

Bermudez, J. (1998), Advanced planning and scheduling: Is it as goods as it sounds?, *The report on supply chain management*, Advanced Manufacturing Research, 1-24.

Bertrand, J. W., Zuijderwijk, M. M., and Hegge, H. M. H. (2000), Using hierarchical pseudo bills of material for customer order acceptance and optimal material replenishment in assemble to order manufacturing of non-modular products, *Int. J. Prod. Econ.*, **66**, 171-184.

Chen, C. Y., Zhao, Z. Y., and Ball, M. O. (2001), Quantity and due date quoting available to promise, *Inform. Syst. Front.*, **3**(4), 477-488.

Chen, C. Y., Zhao, Z. Y., and Ball, M. O. (2002), A model for batch advanced available-to-promise, *Prod. Oper. Manag.*, **11**(4), 424-440.

Fleischmann, B. and Meyr, H. (2003), Customer orientation in advanced planning systems, In: Dyckhoff, H., Lackes R., Reese, J. (Eds.), *Supply Chain Management and Reverse Logistics*, Springer, Berlin *et al.*, 297-321.

Guerrero, H. H. (1991), Demand management strategies for assemble-to-order production environments, *Int. J. Prod. Res.*, **29**(1), 39-51.

Gunther, H. O. (2004), Supply chain management and advanced planning systems: A tutorial, *in Proceedings of the 33rd International Conference on Computers and Industrial Engineering*, Jeju, Korea, 25-27.

Harris, F. H. deB. and Pinder, J. P. (1995), A revenue management approach to demand management and order booking in assemble-to-order manufacturing, *J. Oper. Manag.*, **13**, 299-309.

Jeong, B., Sim, S. B., Jeong, H. S., and Kim, S. W. (2002), An available-to-promise system for TFT LCD manufacturing in supply chain, *Comput. Industrial Eng.*, **43**, 191-212.

Jung, H., Song, I., Jeong, B., and Yoo, W. (2003), An optimized ATP (Available-to-promise) system for make-to-order company in supply chain environment, *Int. J. Industr. Eng.*, **10**(4), 367-374.

Kilger, C. and Schneeweiss, L. (2005), Demand fulfilment and ATP, In: Stadtler H., Kilger, C. (Eds.), *Supply Chain Management and Advanced Planning Concepts, Models, Software and Case Studies*, Springer, Berlin, 179-195.

King, B. E. and Benton, W. C. (1988), Master production scheduling, customer service and manufacturing flexibility in an assemble-to-order environment, *Int. J. Prod. Res.,* **26**(6), 1015-1036.

Lin, J. T. and Chen, J. H. (2005), Enhance order promising with ATP allocation planning considering material and capacity constraints, *J. Chinese Inst. Industr. Eng.*, **22**(4), 282-292.

McClelland, M. K. (1988), Order promising and master production schedule, *Decis. Sci.*, **19**(4), 858-879.

Ozdamar, L. and Yazgac, T. (1997), Capacity driven due date settings in make-to-order production systems, *Int. J. Prod. Econ.*, **49**, 29-44.

Pibernik, R. (2005), Advanced available-to-promise: classification, selected methods and requirements for operations and inventory management, *Int. J. Prod. Econ.*, **93-94**, 1015-1036.

Rudberg, M. and Wikner, J. (2004), Mass customization in terms of the customer order decoupling point, *Prod. Plan. Control*, **15**(4), 445-458.

Xiong, M. H., Tor, S. B., Khoo, L. P., and Chen, C. H. (2003a), A web-enhanced dynamic BOM-based available-to-promise system, *Int. J. Prod. Econ.*, **84**, 133-147.

Xiong, M. H., Tor, S. B., and Khoo, L. P. (2003b), WebATP: a Web-based flexible available-to-promise computation system, *Prod. Plan. Control*, **14**(7), 662-672.

Tamura, T. and Fujita, S. (1995), Designing customer oriented production planning system (COPPS), *Int. J. Prod. Econ.*, **41**, 377-385.

Taylor, S. G. and Plenert, G. J. (1999), Finite capacity promising, *Prod. Invent. Manage. J.*, **40**(3), 50-56.

Ware, N. and Fogarty, D. W. (1990), Master schedule / master production schedule: the same or different?, *Prod. Invent. Manage. J.*, **31**(1), 34-38.

Yeh, C. H. (2000), A customer-focused planning approach to make-to-order production, *Industr. Manage. Data Syst.*, **100**(4), 180-187.