

**SYSTEMIC PERSPECTIVE OF WORK IN PROGRESS AND ON TIME
DELIVERY IN AEROSPACE COMPOSITES MANUFACTURING
COMPANY IN
MALAYSIA**

Rozita Long¹

Shahimi Mohtar²

Fakhrorazi Ahmad³

^{1,2,3} College of Business, Universiti Utara Malaysia,
06010Sintok, Kedah DarulAman, Malaysia
rozita.long@acmsb.com.my

ABSTRACT

This paper explains the significance of managing work in progress (WIP) and its impact on the on time delivery from a systemic perspective in aerospace composite manufacturing company in Malaysia. Research was done within an aerospace composites manufacturing company in Malaysia. A total of four years of data collection on WIP was done and co-related to on time delivery in a linear relationship while applying TOC and RBV. Acknowledgement of WIP as one of critical resources that need to be managed systemically, resource based view (RBV) theory is referred to in explain WIP as a unique, valuable and rare resource that is systemically impacting the whole manufacturing flow. The theory of constraint (TOC) was used to explain the WIP management method through 'pull' and 'push' to create a continuous flow of products to meet the completion date. WIP is one of manufacturing resource systemically impacting the on time delivery. The way WIP is managed contributes a whole lot to the performance and it is critically important in an aerospace manufacturing industry due to its high operations cost. To stay competitiveness in the industry, it is very important that this expectation is met and continuously sustained. Both TOC and RBV theories are complementing each other from a systemic point of view to explain the significance influence of WIP towards the on time delivery in an aerospace composite manufacturing in Malaysia. This paper is originally based on a real, objective scenario and shall be another input to the aerospace composite manufacturing best practices particularly in managing WIP systemically to achieve the targeted on time delivery and to continuously stay competitive in the industry.

Keywords: *On time delivery, WIP, Resource based view theory, Theory of constraints*

INTRODUCTION

In an aerospace composite manufacturing company, completion and on time delivery is critical due to its high operational cost.

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On time completion and delivery depends on the smooth flow of work in the progress (WIP) and consistency of parts movement from start to end. Any delays that happen at any point in the process within the supply chain will cause million of dollar incurred at the end of the supply chain claimed by customer. Eventually it may cause another million dollar loss in sales both to the supplier and customer as what happened to Boeing producing 787 airplane model (Leach, 2009). Thus, as manufacturing entity, it is very important to have a dynamic way of managing the WIP as one of the resources within the manufacturing process. Product and service delivery system is not a straight forward linear relationship as what has been pointed out by Porter who suggested a flow of raw material from suppliers to manufacturers and customers but rather a complex economic and social system involving various inter and intra organizational interactions and relationship (Rouse, 2010). This paper is to highlight the significance influence of how WIP as a unique, rare and value added resource is managed to achieve the on time delivery in an aerospace composite manufacturing company from a systemic perspective based on theory of constraint and resource based view.

BACKGROUND

Among critical resources identified within the company are number of labor, output, output accuracy and WIP. This paper will focus on only one resource; WIP. Strategically, WIP needs to be managed as a whole to create a smooth flow of manufacturing process and generate an accurate output with acceptable quality to meet on time delivery. The shop floor theory states that the amount of WIP does have a direct relationship on the manufacturing lead time (Whybark, 1993) but does the level of WIP has a significance influence on the achievement of the number of on-time delivery? The higher the number of WIP the higher the possibility of the on time delivery will fail due to increase in manufacturing lead time (Lang, 2011). The aerospace composites manufacturing company where the research took place was having inconsistency to meet its on time delivery. However, whether these statements are correct or not, the way WIP is managed pose a significant impact on the completion to meet the on time delivery. According to TOC, a close integrated cross sectional function as a chain of network is the key to successful WIP management (Gupta & Boyd, 2008). This paper will explain the way WIP can be managed systemically to achieve the on time delivery as proposed by TOC.

LITERATURE REVIEW

On time delivery (OTD)

On time delivery is very significant in aerospace industry not because of its high operation cost but also because of limited suppliers producing the aeroplane components part to the primary customer, Boeing or Airbus. The disastrous impact costing millions of dollars due to not meeting on time delivery was experienced by Boeing and Airbus in recent years where delays from suppliers resulted in further delays in their delivery to end customers (Behrens, 2010). Being one of suppliers to major aeroplane producer, an aerospace composite manufacturing company in Malaysia also faced challenges to

deliver on time. The recorded on time delivery from 2008 to 2011 has not been consistent in meeting the target of hundred percent on time delivery (On Time Delivery Report, 2012). To drive the on time delivery, first the definition need to be clarified and understood clearly. The researcher referred to the company On Time Delivery Report 2016, for the definition. The “on time delivery” is defined as the total quantity shipped (per customer requirement) over total quantity (per customer requirement) within the same time period. The shipping date refers to customer purchase order (PO) date. Originally, the requirement or customer PO refers to normal requirement excluding the short notice request, Part On Assembly (POA), Aircraft On Ground (AOG), spare and a short lead time order. However, in year 2014, the management of this manufacturing company decided that the definition of the on-time delivery to include not only normal PO but also POA, AOG, spare and short lead time order (Ontime Delivery Report, Aug2014). The target to achieve hundred percent (100%) on time delivery is not only the quantity but also the right part shipped on time. Literally, delivery is considered on time if the product is shipped on the date specified in the purchase order or demand report or as agreed with customer for the short notice demand. The significance of the on time delivery in an aerospace industry is clearly proven in the failure which caused billion of dollars loss faced by Boeing company. Its priceless lesson learnt with the 787 Dreamliner project delay (Leach, 2009). Boeing failed to address key capabilities and resources in implementing this 787 Dreamliner (Tang & Zimmerman, 2009). Aside from Boeing, Airbus also faced some bad experience as a result of delay in delivery (B. Jorg, K. Andreas, 2008).

Work in progress (WIP)

Literature review on WIP reveals that it is a cost in manufacturing which needs to be managed wisely. An understanding of process and material flow is key to on time completion and delivery (Saraswat, Kumar, & Kumar Sain, 2015). The term WIP is used interchangeably with work in progress referring to “all materials and partly finished products that are at various stages of the production process excluding inventory of raw materials at the start of the production cycle and finished products inventory at the end of the production cycle” as stated in Investopedia. In other words, WIP is a resource that fills up the empty space, boxes and bins between the manufacturing process. Value is added as it moves throughout the process up to the end where it is boxed and shipped to the customer. Without WIP, it is very hard to meet the target. However, too much WIP is a hurdle in the process and too low WIP is a headache since target cannot be achieved. Thus it is very critical to have just enough quantity of WIP in between process. WIP tracking is very critical for manufacturing which handle large volume that require days to complete the process (NetSuite, 2013). Lead time for each product is highly affected by the number of WIP available between the work center. Lower number of WIP is said to result in shorter processing time which eventually end up with on earlier completion time (Whybark, 1993). WIP level within and between processes is to be set per standard formula in the operation book. The level of WIP is impacted not only by the cycle time of each process but also balancing of work load between processes. Standard work in process (SWIP) is a level of work in process that is required to create a smooth flow of product in the production flow that will result in on time completion with optimum utilization of resources. Thus, it is critical that WIP is managed rightfully.

Theory of Constraint (TOC)

The rate of the throughput is another indicator that determines the rate of panel completion to turn into complete panel. It was proven that WIP flow is another constraint that caused delays in completion and lower finished goods inventory level in the company where the research took place. Parts do not flow smoothly due to changes in bottleneck caused an inconsistent flow of WIP. Theory of delays explained delays in WIP flows whereas theory of constraints (TOC) explained WIP using a concept of drum buffer rope introduced by Mr. Eliyahu M. Goldratt's in the early 1980's. TOC provides guideline to manage constraint or bottleneck in a manufacturing company with optimum utilization of resources. The production system is operated by a group of productive labors within the shortest lead time to produce the right quality and quantity required to meet the on time delivery to customers. Comparatively, theory of constraint (TOC) as a broad-based theory is equivalent to total quality management (TOC), just in time (JIT), lean manufacturing (LM), six sigma (SS) and supply chain management (SCM) (Gupta & Boyd, 2008). Implementation of all these philosophies requires systemic thinking mindset as it emphasizes a cross functional integration and decision making (Goldratt Institute, 2009). In other words, it is a cross functional and interdependent organizational processes that views organization as a chain of interdependent processes and functions, processes, departments or resources where various inputs are transformed into various outputs which are sold as throughput. From functional perspective, the weakest link in the chain existed in the whole processes may be an indication of a limited resource that is not fully utilized, insufficient or lacking, thus, need further management attention and action to improve on the interdependent resources and utilization. From operational strategy perspective, it is very crucial that each and every functional unit to be consistent in achieving goal to get to the overall company goals. It is also very crucial to focus on the weakest link in the process to rightfully manage the resources to meet the minimum threshold at the weakest process. Another mindset this theory focuses on is the throughput-world thinking where all the resources are geared towards achieving the most through-put in the overall processes. Finally, TOC suggested that the location of the weakest link or resources is to be identified as it is the key area that the operational strategy need to be defined (Gupta & Boyd, 2008). The concept of bottleneck management applied in the Drum Buffer Rope - Theory of Constraint (TOC) - create a systemic and synchronous manufacturing flow at the shop floor to provide a smooth process from start to end to support on time completion and delivery. TOC proposed that constraint sets the limit for the system performance. In some situation, a high or lower level of WIP can be considered as constraint; whilst in other situation is not. TOC is a concept that provides a view of how the resource can be identified as constraints or not. TOC is a system management philosophy that aims at optimization of total system resources, operation based on the underlying principles where organization makes up of processes that are operated and linked by a chain where the sum of individual process is not the same as the overall system because of the variation and balancing along the flow. TOC assumes the weakest link or process as the constraint that impedes the performance of the organization, thus, the weakest process and link need to be managed diligently to avoid loss of time which eventually will result in late completion to meet on time delivery. The relationship of cause and effect existed in the system resulted in a complex system and the impact to be identified to optimize the performance (Institute of

Management Accountant, 1999). Briefly, Drum Buffer Rope analogy explains how WIP is handled in manufacturing shop floor. The concept of drum buffer rope is part of theory of constraint which is the basis of production flow that literally means the flow of processes linked by a “rope” where the inventory between each processes are well balanced, the next process pulls the previous process inventory. The “bottleneck” becomes the ‘drum beat’ for more orders. The ‘time-buffer’ translates due-dates into release-dates, and the action of choking (or restraining) the release becomes the ‘rope’ that tied the order to the release of work. In fact, it’s how the time-based application of the Theory of Constraints became known as the drum-buffer-rope system (Institute of Management Accountant, 1999).

Resource Based View – RBV

Barney defined resources as *“all assets, capabilities, organizational processes, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness”* (Barney, 2001). Another definition of RBV is *“a determined collection of assets or resources that are tied “semi-permanently” to the firm* (Francisco, 2015). RBV focuses on internal unique resources and capabilities in formulating its strategic decision making to achieve performance while Porter’s five forces focus on the external environment. There was documented evidence proposing a significant relationship between organizational resource, capabilities and system and competitive advantage and the RBV is the right approach to deploy (Ismail, Rose, & Uli, 2012). To sustain the competitive advantage, an organization must continuously develop current and new resources and capabilities in responding to the market condition and requirement.

Resource Based View versus Theory of Constraint View Assumptions

How can we explain Resource Based View theory in relation to the Theory of Constraint? Resource based view theory focuses on unique, valuable and rare resource and capabilities deployment through value add activities to achieve sustainable competitive edge (Bridoux, 2003) whereas the theory of constraint focuses on well balanced process management by elevating and managing identified constraints (Institute of Management Accountant, 1999) to reach optimum result. Both theories are system focused emphasizing optimum utilization of internal resources and capabilities. WIP in manufacturing is a resource that requires a close and consistent deployment to create a smooth flow of product at the shop floor. Theory of constraint is a mechanism that defines a way to manage constraints resource throughout the manufacturing process to create a smooth flow of resource and process. While RBV is focusing on the internal resource deployment, TOC is focusing on identifying the right resource to focus on. Thus, both theories emphasize on overall systemic integrated functions within the company.

Theory of Constraint – Applications

TOC is applicable in various areas of practices such as supply chain, engineering process improvement, marketing, manufacturing and administration by various companies

globally including organizations such as Avery Dennison, Bethlehem Steel, General Motors, National Semiconductor, United Airlines, Boeing, ITT and Procter and Gamble. Not to forget the United States Air Force Logistics Command also has adopted constraint management concepts to improve the performance of aircraft repair depots, while the United States Navy has implemented TOC concepts in its Transportation Corps (Institute of Management Accountant, 1999). Its application is not limited to profit organization only but also to non profit organization throughout the globe.

In manufacturing companies, TOC suggested a 5 steps focusing process method to improve and manage the process. The first step is to identify the constraint within the system. Constraints that exist within the system sometime are not always visible to the process owner. It is very important for the area owner to identify and firmly agree that the identified constraints are the limiting factor that is slowing down or preventing the team to achieve the goal. The second step is to decide how to exploit the constraints. Once the limiting factor is identified, the constraint must be exploited. At this stage, decision need to be made either to move or stop, increase or reduce certain capacities or activities in order to effectively deployed the constraints or resources to meet the system target. The third step is to subordinate everything else to this decision. Management priority must be to focus on improving this identified constraints, nothing matters most except this constraints. The fourth step is to elevate the constraints. At this stage, capacity and resources required to improve the constraints is treated top priority and eventually this constraints is taken care off. Finally step five, repeat the first step. This close loop process must be continuously practiced and improved. Operational constraints may not stop at five steps at the same spot every time. It moves and by going through these 5 steps focusing method believes that the constraints will turn into opportunity that can bring better results than issues (Institute of Management Accountant, 1999).

Theory of Constraints – Limitation

TOC is not without limitation. One of the limitation is TOC does not explain how to identify the bottleneck or constraint. The second limitation is lack of consideration on variables factors. It does not provide a way to determine the exact constraints resulting in resource waste if the constraints identified is not the root cause of the constraint. TOC only provides a short term solution as it looks at the actual current situation. The process of identifying the real cause of the constraints is a truly trial and error process which needs to be done continuously. However, usage of TOC is still a favorable effort by companies due to the benefits that result from a continuous improvement, increase responsiveness and flexible in priority setting; and one process delay will cause another to slow or stop operating (Institute of Management Accountant, 1999).

Resource Based View – Application

Resource management process incorporates feedback loops which allow continuous adaptation for synchronization and fit with the environment; thus, it is dynamic, with changes resulting from adapting to environmental contingencies and from exploiting opportunities created from and by those contingencies. To have a full advantage of the result, managers must be able to adapt and adopt the structuring processes in order to

synchronize the resources to create optimum value to the customers. In short, managers must have the ability to develop and diverse resources to have the optimum resources utilization, the ability to bundle resources in order to create effective capabilities and finally managers must have the skill to leverage so that the most effective co-ordination is created. Critical skill that managers must have is the ability in understand the feedback loop and learn process to continuously upgrade the capabilities

Resource Based View Theory Limitation

In many literatures, it has been pointed out that there are two reasons that still implicate this resource based view theory. First, it lacks a single integrating framework and thesecond there is limited effort to develop the practical application of the resource based view theory (Robert, 2001). This is supported by Williams, T. et al (2002), who commented that the major problem with the resource based view in strategic formulation is the limitation on mechanism to translate its resources and capabilities deployment concept into a practical meaningful diagnostic and prognostic managerial capabilities (Hax and Mjluf, 1996). Thus, the RBV practicality is still called for some basic grounded concepts within the practical framework. Its application has been tested relatively in the area of key activities in the industry inclusive of entrepreneurship, innovation, manufacturing competition and performance, market driven manufacturing, demand chain management and industry catch-up strategy for latecomer firms. The application of the Resource Based View theory of the firm has been made difficult due to the complexity of the process. An example shared by David N. Ford is in the telecommunication network operator in managing the national market liberalization. An organization should develop a strategy as guideline to move forward in manipulating the resources to gain and sustain its advantageous position (Black and Boal, 1994). To get the theory in place, first and foremost, the definition of the word “operationalization” and the reason for the operationalization need to be clearly understood. “Operationalization” is defined as “a formalization of the theory’s ideas and concepts into applicable models which facilitate all stages of strategy formulation and decision making”.

CONCLUSION

A total of four years of data collection on WIP was done and co-related to on time delivery in a linear relationship while applying TOC and RBV. Acknowledgement of WIP as one of critical resources that need to be managed systemically. WIP is an asset and resource that must be managed and deployed to as minimum as possible to the standard level so as to optimize the resource (labor and machine) utilization in generating sales to the company. RBV and TOC are rather complementary theories than the opposite. TOC specifically touches on identifying constraints to manage the WIP. Application of TOC is said to generate advantages to the company. Among the advantages are decreased production lead times; improved quality of products and services; dramatic increases in profitability; reduced inventory levels; reduced bottlenecks; management of constraints; curbing of statistical fluctuations; improved competitive position; facilitation of strategic marketing and operational decisions; introduction of the marginal pricing concept; and application of continuous improvement

at the supply chain level. Personally, from observation and working at the shop floor, the application of TOC and RBV in the composite manufacturing company where the research took place is highly recommended. Theory of Constraint (TOC) is a theory to explain WIP management through drum-buffer rope analogy in the manufacturing companies (Institute of Management Accountant, 1999). RBV focuses on activities to optimize resources and capabilities as the bases for achieving sustainable competitive advantage (Francisco, 2015). Both TOC and RBV can be combined to complement each other to provide better mechanism and methodology to manage WIP in the aerospace composites manufacturing company in Malaysia.

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