Title: A Critical Review of " The Historical Roots of Concurrent Engineering Fundamentals"

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Abstract: A paper titled "The Historical Roots of Concurrent Engineering Fundamentals" is critically reviewed in this individual report.

A Critical Review of " The Historical Roots of Concurrent Engineering Fundamentals"

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I. Introduction

Concurrent engineering (CE) is a method that has been used ubiquitously nowadays. Seemingly, many companies attempt to adopt or will adopt CE concepts into their organizations as a key to survive in the ferocious competitions. The term CE has been mentioned since the 1980's. However, with the observant investigation of a researcher, Robert P. Smith [1] concluded that CE has existed for a long time, but it has not been widely adopted and named as it does today. CE became attractive since the success of Japanese companies as [2, p. *xviii*] mentioned "Concurrent engineering is believed to be the critical factor in competitive leadership for Japan!"

The purposes of this paper are to summarize and evaluate the article "The Historical Roots of Concurrent Engineering Fundamentals," by Smith [1]. The article studies CE in the following fields; concepts of CE, incentives to adopt CE, methodologies before CE, descriptions of design-for-manufacturing/design-for-assembly (DFM/DFA), customers' roles in the design process, and presumptions why CE ideas were not widely used.

II. Concepts of concurrent engineering

Many scholars have given definitions of CE in many ways. "The simplest definition of concurrent engineering is the simultaneous development of product and process," stated Thomas A. Salomone [4, p.1]. However, the widely accepted one was defined by the Institute for Defense Analyses (IDA):

> Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacturing and support. This approach is intended to cause developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule and user requirements.

From [1], it has four categories in CE fundamental.

- Increasing the role of manufacturing process design in product design decisions.
- Using cross-functional teams to implement the development process.
- Including customers' desires into the development process.
- Reducing time-to-market to increase competitiveness.

Similar to [5, p. 5], CE also has four categories: 1) changing rate of product and process definition, 2) shortening cycles for new product introductions, 3) manufacturing product with high complexity to meet customers needs, 4) using multiple design teams for a single product.

CE will spend more resources in the designing stage to make products high quality and low cost. From [4, p.19-20], Salomone mentioned "A high percentage (some report as high as 80%) of product quality is locked in at the time of design." Moreover, from [5, p.35], Miller showed that design has about 70% on product's final cost, but has only 5% on proportion of the final cost. An error in designing can cause a product unproduceable or costly to produce; additionally, the product can miss its target.

III. Incentives to adopt concurrent engineering

With high change rates and competitive nowadays, businesses have to improve their products to be able to compete with others. Smith [1] has provided three main factors that push manufacturers to adopt CE for compete with other firms in marketplaces.

A. Increased competition

The first main reason that drives manufacturers to improve product development process is an increased competition. Competitive products should have high quality and low cost. The effective design is one of the important components that make such products. Smith [1] claimed that the high rate of competition is not new in marketplaces. It has been in the marketplaces all the time.

B. New production methods

With new production methods, product designers have abilities to design a product in more complexity. Automation is included into processes to increase efficiency of products. Product engineers and design engineers should cooperate to ensure that designs could be produced.

C. Lead time.

Time to market is one of the most important incentives to adopt CE. The simultaneous designing can reduce time of concept to product with high rate. From [2, p.56, 63], with concurrent design can reduce lead time by 40 to 60 percent.

Moreover, Salomone [4, p.2-4] also described three reasons that design should be concurrent. The first one is *rapid pace of technology.* Because of high technological changing, companies that cannot catch up the technology curve are hard to survive in marketplace. The second one is *forced design cycle compression.* As mentioned above, high change rate and shorter time to market impel designers to have shorter products' life cycles. Finally, *emerging information technology and methodologies* is the last factor. With high technology tools such as computer-aided design (CAD), computer-aided engineering (CAE) and several of electronic communication, design teams can do their job faster and more efficiency.

From [3], Haddad mentioned "concurrent engineering is a way of attaining three key business objectives simultaneously: 1) reducing time-to-market, 2) improving product quality, and 3) lowering product development costs."

IV. Methodologies before concurrent engineering

From [1], There are four methods that have been used to accomplish teams' integration before CE:

A. Requiring approval by other functions

Integration of functions needs to involve with many departments in manufacturing. To work with many groups of functions, product designers need approval by them to ensure that they will cooperate properly and provide higher chance to succeed. However, [1] commented that even though teams have an approval from departments, ability of the teams still be limited by departments' cultures.

B. Using liaison personnel

Liaison personnel are teams that will cooperate with every department that concern in product designing. These teams are not members of any functions in the organization.

C. Meetings between representatives of different functions

This method is to have a meeting of departments regularly and discuss about progressions of design. It has two types of the representatives in the meeting. The first one is the representatives are heads or seniors of functions. In this case, the representatives can make decision for their own function. Another type is the representatives are personnel who work directly in the process. These personnel can describe more detail in the processes.

D. Using cross-functional teams to accomplish integration

"This approach is closer to concurrent engineering practice," mentioned by [1]. Cross-functional teams are the teams that combine with expert in engineer, production, marketing and other functions that involve in a product design. The teams can be formed whenever needed, and one team has to work for only one specific job. The cross-functional teams will be disbanded after the job is finished.

V. Descriptions of DFM/DFA

Design-for-manufacturing (DFM) and design-for-assembly (DFA) are the term of techniques that use in CE. In some literature such as [2, p. 23] combined those terms into one called design for manufacturing and assembly (DFMA). These methods are concern about designing a product to be easy for manufacturing or assembly. From [1], Smith concluded "A design can be improved by paying attention to its manufacturing process early in product development."

Furthermore, from [2, p. 146-148], Hartley provided some general rules for DFMA such as: use the minimum number of parts, make design modular, design part to be multifunctional, minimize assembly directions, minimize handling, eliminate or simplify adjustment, and avoid components made from flexible materials. With DFMA, as shown in [2, p. 155], Texas Instruments can reduce assembly time by 84%, total number of parts by 75%, and number of operations by 77%.

VI. Customers' roles in the design process

From experiences of U.S. companies in automobile industry in late 1970's, consumers' desires can effect the industry as [3] mentioned "Productivity served as the dominant competitive paradigm until the late 1970's, when Japanese auto producers took the lead in focusing upon quality as a key business strategy. Consumers responded by giving a growing share of the U.S. auto market to Japanese firms." For every product, designing must have goal to meet the consumers' needs as [1] stated "The ultimate goal of a development project is to create a product that makes a profit. The role of the customer who will pay for the product needs to be addressed during development."

Additionally, assume that a product is a technology. Once, Dr. Dundar Kocaoglu concluded, "If technological purity does not match market reality, the endless search for excellence can bleed the company to death," which means if a product design is not match market's need (market reality), that design is worthless.

VII. Conjectures of lack of adoption

From [1], five conjectures are provided as the reasons of why CE just has been adopted ubiquitously in last two decades, not in earlier period.

Conjecture one: New processes have more complexity. Then the need of CE is become more critical. However, from [1], "It may be true that newer manufacturing processes require greater design-manufacturing interaction during the first years of their application, but as a manufacturing process becomes well understood the design needs may stabilize and no longer require extensive cooperation."

Conjecture two: Electronic communication and other technologies make the cross-functional teams do their jobs easier.

Conjecture three: Old organizations' cultures are the obstructions of CE. As [1] said "Concurrent engineering practices were not easily applied in existing functional organizations."

Conjecture four: Academic system trained engineers in some fields that did not about designing a product to be easy for manufacturing or assembly. From [1], Smith concluded "A design can be improved by paying attention to its manufacturing process early in product development."

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Conjecture three: Old organizations' cultures are the obstructions of CE. As [1] said "Concurrent engineering practices were not easily applied in existing functional organizations."

Conjecture four: Academic system trained engineers in some fields that did not provide a chance to learn newer and better practice.

Conjecture five: Due to ferocious competition, cycle time of products is shorter. A company that can have shorter time-to-market will have an advantage. Hence, CE is one of the solutions.

VIII. Evaluation

From the article [1], the author used many documents from textbooks as a methodology to support his idea. "The concurrent engineering ideas have existed for a long time, but were not put into practice both because older methods seemed easier and because the educational system did not advocate sufficiently a change to preexisting practice. Educators and researchers have the duty to ensure that this does not happen again," said Smith [1]. This article describes clearly and has a lot of solid evidences to strengthen the author's idea. Furthermore, from the result of the article, the author gave a very useful suggestion that educators in literature should support an innovative idea such as CE to gain acceptance from educators and researchers easier. This field of research is not frequently written. The author mentioned that there is only one paper in the same field "Concurrent engineering 's roots in the World War II era," by M.C. Ziemke and M.S. Spann in "Concurrent engineering: Contemporary Issues and Modern Design tools." Unfortunately, I could not find that article to compare with [1].

IX. Summary

This paper summarizes and evaluates the paper [1]. Moreover, it is included concepts and further information from other sources in order to compare with the information from [1]. Nonetheless, with the specific field of [1], it is hard to compare directly in the field of historical roots of concurrent engineering. This field of paper should be encourage to be written for supporting researchers to innovate new wisdom for academia.

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