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Mass Customization Strategies in the Computer, Automotive, and Retail Industries: Trends and Analysis

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by

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1. **Introduction:**

1.1 **Overview of Mass Customization**

Simply put, mass customization is mass production of individually customized goods or services. Understandably, this is a paradox: how can one mass-produce a product, when each individual product is customized? It seems to make no sense. However, by understanding how companies apply specific strategies with regard to product design, manufacturing, and supply chain networks, the concept of mass customization becomes easy to understand. One simple strategy, for example, is to use a high percentage of common parts across many different products in the design and the manufacturing processes, and ultimately "customize" each product at the last possible moment before the customer receives the product by a technique known as postponement. Another strategy is to design current products with foresight such that undeveloped future products will use the same parts, which saves money in future design processes and also reduces long-term manufacturing costs.

The concept of mass customization, however, has expanded in the last several years, and many new strategies have been developed by companies seeking a competitive advantage in their respective markets. These new strategies include many ways of delivering a customized product to the customer as quickly and cost-effectively as possible. Companies are now doing a variety of things, including inventing new technologies and products, eliminating customer duties, developing new types of jobs/positions within their companies, developing agile infrastructures, and moving business to the Internet in order to mass customize most economically. Dr. A. Toffler initially predicted the concept and eventual development of mass customization in his

book, Future Shock, which was published over 30 years ago in 1970. Stan Davis eventually coined the term "mass customization" in his book Future Perfect, published in 1987. Initially, the concept of mass customization was basically, "variety and customization through flexibility and quick responsiveness", but now it has grown to mean, "the (whole) process involved in giving customers exactly what they want exactly when they want it" (Anderson, 1997). The definition, and thus the concept of mass customization, has clearly expanded in the last decade.

The concept of mass customization has evolved over the past two decades in the business world due to increased customer expectations, which were caused by advances in several areas of technology. Marketing and manufacturing processes as well as computing and information technologies have become more sophisticated, which has led to increased competition in the business marketplace. Other notable advancements, such as flexible manufacturing technologies, just-in-time systems, cycle-time reduction, and time-based competition have also emerged as a result of these technological advancements. This paradigm shift in the business world, from mass production to mass customization, is also due to the fact that customers cannot be viewed as a large homogeneous group (mass production viewpoint) anymore, but rather each customer must be considered as an individual with specific needs and wants to be fulfilled (mass customization viewpoint) (Pine, 1993).

A myriad of examples exist of companies that have shifted (or been "forced" to change in order to survive) from mass production to mass customization. A good example is the fast food industry. Fast food industries were a paradigm of mass production. However, with the change of the concept of the customer (now a customer

must be considered as an individual with specific needs and wants to be fulfilled), these companies, e.g., McDonald's, Burger King, Subway, etc., have been forced to embrace principles of mass customization in order to survive (Mok, et al., 2000). Other examples exist of companies that are pioneers in mass customization. Dell Computer, for example, initially started by mass customizing its products and has been very successful.

The goal of mass customization is "to provide sufficient variety in products and services so that virtually every customer is able to purchase a customized product for a price near that of a mass-produced item" (Duray and Milligan, 1999). In other words, mass customization is, "giving customers exactly what they want, at the price they want, and at the time they want it" (Duray and Milligan, 1999). Therefore, cost savings for companies and lower prices for customers while simultaneously providing high product variety is in essence the goal of mass customization. Many strategies can be implemented in order to mass customize products most economically, i.e., with the lowest cost for the company and the lowest price for the customer. These different types of customization are classified in the next section.

1.2 **Types of Mass Customization**

Gilmore and Pine (1997) identify four basic types of mass customization as shown in Figure 1:

(1) collaborative customization – working directly with customers to identify their specific needs and how to fulfill those needs and make customized products for them.

(2) adaptive customization (embedded customization) – offering a standard product which customers can alter themselves in order to customize the product to their needs.

(3) cosmetic customization – presenting a standard product differently to different customers by using customized packaging, advertising and marketing techniques.

(4) transparent customization (the opposite of cosmetic customization) – using standard packaging for products that have already been customized, unbeknownst to the customer.

The choice, concerning which type of mass customization to use, is for the most part, product dependent. Adaptive customization is appropriate with an automobile, e.g., from a basic model a customer can easily customize the car with a myriad of options. On the other hand, cosmetic customization would be appropriate when selling for example candy or nuts as Planter's Corporation did by retooling its manufacturing facilities. The retooling enabled Planters to package different volumes of nuts and candy in different forms geared towards pleasing different customers.

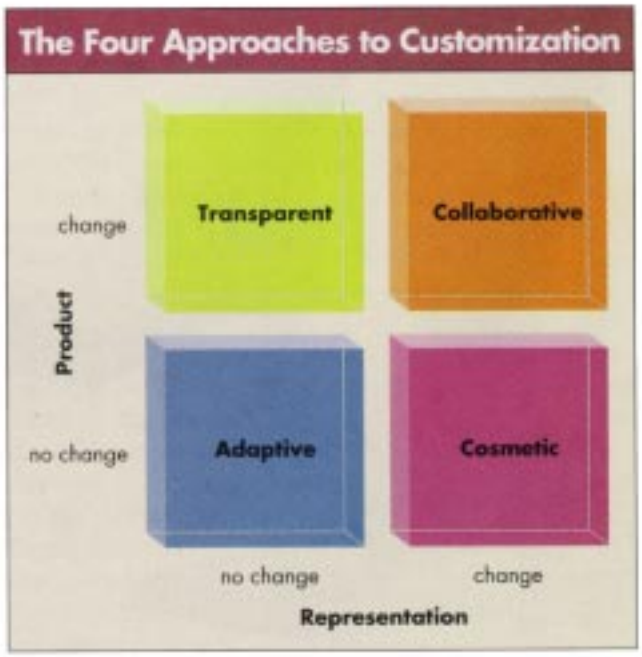


Figure 1: The Four Approaches to Customization

Thus, several specific elements are required for a company in order to successfully mass customize in today's business world. Companies must use reliable suppliers that can consistently provide just-in-time deliveries with high quality parts. Companies must have agile infrastructures; this includes, for example, manufacturing processes that are agile and can thus promptly adjust to changes in customer demand and product variety, while providing the end customer with a timely product delivery. Each company must use the best current technologies and the best suppliers at each stage of the product production process (from initial design to final product delivery to customer) in order to optimize its specific mass customization strategy (Duray and Milligan, 1999). A very in-depth understanding of the customer is also a key. Thus, the aforementioned conditions are necessary for successful implementation of mass customization; however, the ultimate decision of whether to actually pursue a mass customization strategy at a company requires many other considerations.

1.3 **Determining Shift to Mass Customization and its benefits**

A company must consider many key factors before pursuing mass customization. First, customers of the company must want product variety with customized products. Second, the company's process technology must be able to customize products for individual customers. Third, the company must be able to afford new technology, which could be required to mass customize. The company must also have a marketing department that can provide a sufficient level of detail of customer needs and wants. The company must be able to design customized products, i.e., translate customer needs into actual specifications. The company must be able to produce and distribute customized

products, which requires a flexible production system. The competitive environment of the company's specific marketplace must also be considered, i.e., would it benefit from mass customizing products and services? Finally, the company must be able to handle the significant change from an organizational structure viewpoint, which will come about when (if) it implements a transition to mass customization. In other words, each company must consider its own products, resources, and capabilities in order to make a final decision. In summary, "mass customization must be customized to a particular organization's customers, production capabilities, competitive situation, and the new technology available to them" (Mok, et al., 2000). A mass customization strategy that works for one company may not work for another.

There are also many financial advantages to mass customization. Companies have generally noticed that after their new mass customization systems are in place a new mass customized product price is just slightly less than with the former mass production technology (Anderson, 1997). Also, many customers are willing to pay a premium for a customized product, anywhere between 10-50% depending on the type of product (Anderson, 1997). Therefore, the financial implications are clearly beneficial, because margins have increased by offering a customized product. Also, during the mass customization process many companies reduce the need for, and thus the cost of, finished goods inventory, which is an added source of financial savings (Anderson, 1997). Additional savings can also result from streamlining processes, which most often occur as a result of mass customization. Finally, many new technologies also streamline production processes, and therefore companies save additional money.

Generally in mass customization, economies of scope are used to maintain low

costs rather than economies of scale. "Economies of scope are realized by the application of a single process to produce a greater variety of products and services more cheaply and more quickly" (Pine and Maskell, 2001). Therefore, in order for this single process to be successful, it needs to encompass adjustments and changes in many things, including management, manufacturing, design, quality control, product variety, time from initial order to final delivery, etc. It is especially important for companies to make sound decisions with regard to capital investment for manufacturing equipment in order to enable economies of scope to occur. In other words, management must be careful to invest in manufacturing equipment that can be extremely flexible, respond rapidly to product changes, and have greater predictability. Software also must be chosen carefully so that it is technically capable to make application of leading-edge processes feasible with high product variety. A successful economies of scope scenario from a manufacturing standpoint exists, "where the same equipment can produce multiple products more cheaply in combination than separately," (Goldhar and Jelinek, 1983).

1.4 **Goal in This Paper**

1.4.1 Research Involved

The author of this paper analyzed numerous books, written by recognized authors in the field of mass customization strategy. Other key sources of information, such as the Wall Street Journal and the Harvard Business Review, were utilized. Finally, numerous search engines on the Internet were used and several articles were obtained written by companies and other authors.

1.4.2 Organization of Work

This paper examines the current strategies that three industries are using in today's world to enable economic mass customization of their products. Specifically, the computer (industry #1), automobile (industry #2), and retail (industry #3) industries are analyzed. At least three companies within each industry are discussed to illustrate specific strategies that are being implemented to successfully lower costs while maintaining product variety. General trends are also outlined within each industry. Other notable companies and their respective mass customization strategies are also discussed. General patterns across all industries addressed in this paper are identified and discussed. Finally, a brief discussion focuses on how mass customization may metamorphasize in the near- and long-term future with respect to today's constantly changing business world.

2. **Industry Examples:**

In this section, three industries are examined. The computer, automobile, and retail industries were specifically chosen for analysis because they are generally recognized as those large industries that are on the cutting-edge of advancements and use of technology in mass customization in today's business world. Thus, by analyzing the mass customization strategy trends of the aforementioned industries, this paper examines the current strategies for mass customization.

2.1 **Industry #1 – Computer Industry**

The computer industry can truly mass customize its products because of the small numbers of parts in its products, i.e., approximately 30 parts per computer (Simison, 2000), as well as the more flexible manufacturing processes its parts enable. Moreover, computer products can be easily marketed and customized via the Internet.

Three computer companies are examined: DELL, because it has been a pioneer in mass customization and been very successful at keeping up with the changes in the industry, and International Business Machines (IBM) and Hewlett Packard (HP), because they are widely recognized as two of the most successful computer companies in history and have been major contributors in worldwide technological advancements in the computer industry over the last 50 years.

2.1.1 DELL Computer

DELL Computer was started by Micheal Dell in 1983 and was a pioneer in mass customization. Mr. Dell basically developed what he called the Direct Model, which involved building a computer exactly to customer specifications. In essence, he started by customizing his product, and as his business grew, he began to expand and mass customize. By 1987, DELL was the first personal computer company to offer next-day, on-site product service. Also in 1987, DELL began international expansion with the opening of a subsidiary in United Kingdom. In 1993, Dell joined the ranks of the top-five PC makers worldwide. In 1997, Dell shipped its 10-millionth computer system. Finally in 1999, sales via the Internet reached $40 million per day. One main reason DELL has been so successful is because of its understanding of its customers' needs and

its ability to react quickly to those changing needs.

DELL sells two basic products, one for the individual consumer and one for corporate networks. Consequently, DELL defined two types of customers and assigned teams within the company to help customize services for the two groups of customers. The two types were: (1) transaction buyers, i.e., private consumers, who bought customized home computers for about $1,250, and (2) relationship customers, basically large companies and institutions, who placed large orders repeatedly (Rangan, 1999). In 1996, DELL launched its web site at www.dell.com (see Appendix), and transaction buyers used this site on the Internet increasingly to contact DELL. Shortly thereafter, buyers could actually design a computer on-line, check pricing, place an order, and track an order's progress. "Almost immediately DELL began selling 1 million dollars per week through the Web" (Rangan, 1999). "Incredibly, by December of 1998, transactions on www.dell.com totaled about 10 million dollars per day" (Rivkin, 1999).

Also, in 1998, DELL expanded its services by designing custom "Premier Pages" (secure Web pages on the Internet), which helped to improve customized service to relationship customers. These Premier Pages have also been used as a way to build individual customer histories, in essence, becoming a form of a customer integration strategy. A customer integration strategy is essentially building an integrated information flow that not only covers one transaction but also builds a knowledge base of customers for the whole company by information gathered during fulfillment of customer specific orders. This strategy also integrates customers and suppliers in all stages of the process to facilitate mass customization.

The Internet has offered several other business advantages to DELL. For

example, DELL has replaced hard copy manuals with electronic downloads which has saved millions of dollars each year. Technical service has also been improved at DELL by using the Internet; the technical support staff can now electronically upload system information before the start of a service call, which reduces service call times by about 10% (Rangan, 1999). In addition to the hardware, DELL developed a program called DELL Financial Services, which offered the customer installation of software, leasing, and technology planning and asset management services (Rivkin, 1999). Hence, DELL has expanded its services to satisfy customers individually, improving overall customization.

DELL uses a collaborative approach to mass customize and assembles computers to customers' exact specifications. It surpassed IBM in early 1998 to claim the second spot in personal computer market share.

Reduction of inventory, and thus costs, is a key to success in the fast-paced, ever-changing computer business. DELL has been able to reduce inventories from 31 days in 1996 to only 6 days in 2001 (Valencia, M., 2000). DELL reduced its inventory by outsourcing its production up to the latest point for final assembly. This technique is known as postponement and can be outlined as follows. Basically, it is a process, which delays the point of product differentiation in the production process, in order to provide high variety in a cost-effective manner. Postponement has two main advantages: (1) it offers flexibility, which allows the company to monitor the latest demand for different end-products and then determine how to customize the standard product according to the data and time frame, and (2) it enables a company to more accurately forecast the demand of future products, because the process allows "the decision concerning the final

customization of the end-products to be made at a time when the demand forecasts of the end-products are improved" (Ho and Tang, 1998).

Also, DELL ensures that all suppliers in the supply chain know correct information about customer needs and thus have been successful in its postponement process. "Speed and good communications processes are essential in successful mass customization," as can be seen in the case of Dell (Massenproduktion, 2000). In other words, although DELL was a pioneer in mass customization, it has constantly changed and expanded through time its overall mass customization strategy in order to satisfy the ever-changing demands of its customers.

The current focus of DELL in 2001 is to stay focused on how to use the Internet most efficiently to serve customers, because other competitors have implemented their own web pages and services in order to compete with DELL. DELL does not seem to be worried, however. As a DELL top management executive, Morton Topfer, stated, "We see the online initiative along with our initiatives in servers and workstations as critical in our drive towards continued growth and profitability for DELL" (Rangan, 1999).

2.1.2 International Business Machines (IBM)

IBM, as far back as the 50's, has continually introduced new and impressive products to the computer marketplace. As early as 1952, IBM introduced RAMAC™ (Random Access Method of Accounting and Control), the first computer disk storage system. In 1963, IBM introduced the first disk drive with a removable disk pack (IBM 1311). In 1970, IBM invented the floppy disk, which would usher in the era of data portability and desktop computing. In the 1980's, IBM introduced data compaction,

which enabled disks to hold much more memory per disk, enabling much more computer power. Most recently, in 1999, IBM set a new world record in hard-disk-data-storage density by writing and reading 20 billion bits (20 gigabits) per square inch in a laboratory demonstration (http://www.storage.ibm.com/hdd/firsts/1990.htm). Therefore, IBM has been a major contributor to worldwide technological advancements in the computer industry.

IBM began as a mass producer of computers, but in the last decade it has changed its strategy and focused on mass customization as a way to keep up with the competition. The basic model used by IBM to implement mass customization involved five basic steps: 1) customizing services around existing standardized products or services, 2) mass producing customized services or products that customers could easily adapt to individual needs, 3) moving production to the customer to provide point-of-delivery customization, 4) providing quick response to customers, and 5) modularizing components to customize end products and services (Pine, 1993).

Step #1 involved mass production of products with customized services. This step allowed IBM to demand a premium price for its product, which gave its manufacturing operations time to develop their own techniques of mass customization. Its goal was not just to offer customer service but rather give the customer an "individual experience."

Step #2 focused on customizing each customer's individual IBM system environments. Most hardware and software developed by IBM is compatible with many different computer systems and thus a wide range of customers. At this point, IBM was focused on providing customized customer service while still relying on a standard

product.

Step #3 involved integrating production and delivery. IBM focused on reducing lot sizes, eliminating non-value added time, and using information technology to speed the response and make customization economical.

Step #4 focused on responding to the customer more quickly. This pushed the entire organization to mass customize both products and services. Since part of the computer industry involves time-based competition, this stage helped because it reduced the time IBM products spent in its value chain. This staged finally culminated in its final stage of mass customization.

Step #5 involved developing modular components in order to achieve maximum individual customization. This enabled IBM to gain economies of scale through components rather than whole products. Also, the repeated usage of the same modular parts in many different computers resulted in economies of scope. Finally, IBM had a mass customization system in place (Pine, 1993).

In order to keep up with its competitors and constantly changing customer demands, IBM recently developed an Internet web page to help customers customize and purchase computers on-line. IBM has two basic types of products: (1) laptops and (2) desktops. IBM has thus focused on how to mass customize each of these products on the Internet most efficiently. The web page, at www.ibm.com (see Appendix), allows customers to choose customized options from its standard models, which is basically an adaptive mass customization strategy. After an analysis of the web page, one can conclude that customers can clearly get anything they want, i.e., any combination of computer configurations and capabilities.

IBM is therefore also pursuing the Internet as a way to individualize customer needs, including products and services. On its web page, there is easy access to assistance for technical support and strategic decision making when analyzing what kind of system to purchase, via an "on-line advisor." Buyers can therefore customize, purchase, and track their purchase via the Internet with their customized order (www.ibm.com, 2001).

The next question becomes, how is IBM accomplishing this on-line customizing service behind the scenes, i.e., from a manufacturing and supply chain perspective? IBM has worked hard to develop an agile manufacturing system. In order to improve overseas manufacturing facilities, IBM created a joint venture with Display Technologies, which effectively leverages "the respective design expertise of the participating organizations (IBM) and ferrets out manufacturing capability abroad." In addition, by making its manufacturing facilities more flexible within the U.S., it has essentially been successful in forming a network of manufacturing facilities to provide a broad base of manufacturing tools and processes, thus developing an agile infrastructure. By having manufacturing facilities in place that share databases, information networks, product and process modeling tools, intelligent process control, and data transfer standards, IBM can quickly change production to different products without increasing costs (this is in essence the definition of an agile manufacturing system). Thus it has developed a good agile manufacturing system, which allows IBM to capitalize using the Internet as the mass customization "tool" for the customer (Sanderson and Uzumeri, 1997).

2.1.3 Hewlett Packard (HP)

HP, as far back as 1938, has also continually contributed to technological advancements in the computer industry. In 1959, HP became global and opened a large manufacturing facility in Boeblingen, Germany. Today, HP has offices in more than 120 countries. In 1968, HP introduced the world's first personal computer, the HP9100. In 1972, HP introduced the world's first handheld scientific calculator, the HP 35. In the 1980's, HP entered the printer market, as well as redesigned its organizational structure. Finally, in the 1990's, HP introduced a series of impressive new products, as well as redesigned its organizational structure yet again, due to the rapid changes in the computer industry (http://www.hp.com/hpinfo/newsroom/hpads/1999/timeline/timeline.html). Hewlett Packard has two basic products: (1) personal computers and (2) network systems; however, most of HP's business is with its network systems. HP has been successful with mass customization as a result of combining different mass customization strategies including modular product design as well as product postponement. HP developed its mass customization program as follows: 1) it designed products consisting of modules, which could be assembled in different combinations easily and inexpensively in order to produce a wide variety of products, 2) it designed their manufacturing processes to consist of independent modules in order to easily support different distribution-network designs, and 3) it focused on changing its supply network in order to provide two main capabilities: a) be able to supply basic product to the facilities performing the customization in a cost-effective manner, and b) have the required flexibility and responsiveness to take individual customers' orders and deliver them quickly to customers (Feitzinger and Lee, 1997). In essence, HP focused on increasing

the agility of its overall infrastructure, including its design and manufacturing processes, as well as its supply chain networks.

In addition, Hewlett Packard has also developed a web page similar to its competitors in order to keep up with them. The web page has been made possible by the creation of the aforementioned agile infrastructure. Many of the features of the Hewlett Packard web page at www.hp.com (see Appendix) are similar to those of the IBM web page, i.e., offering very basic standard products, which can be customized almost in any way, shape or form, via "add-on features", leaving the customers the ability to purchase all possible combinations of HP products (adaptive customization).

2.1.4 Other Major Competitors in the Computer Industry

Gateway and Compaq have developed agile infrastructures and thus also been able to develop web pages via the Internet, in order to offer customized products on-line, similar to those of their competitors.

2.1.5 General Trends in the Computer Industry

Based on analysis of these three companies, it appears that all computers are now being designed in a modular fashion, which allows for flexible manufacturing capabilities and also postponement. This improves the ability of the company to quickly deliver a wider variety of customized products to their customers. Recent trends to improve economic mass customization include the following.

(1) Applying the concept of agility, i.e., by developing an agile infrastructure (being fast as well as flexible with respect to product delivery and changing individuals' customized

needs) in different forms. For example, HP improved the agility of its manufacturing systems by redesigning them, i.e., designing their manufacturing processes to consist of independent modules in order to easily support different distribution-network designs, due to fast changing business environment; this is an example of an agile manufacturing process, one which can increase its speed without increasing costs (Pine and Maskett, 2001).

(2) Use of the Internet by developing company web pages in order to sell customized products.

(3) Maximizing the use of the Internet to expand services, i.e., those including customer support, buyer decision making, technical support, etc.

(4) Using customer integration strategies by building an information database of individual customer histories in order to enhance future customization for each individual customer via the Internet.

(5) Strategizing to discover how they can use the Internet even more efficiently to economically capitalize on their respective mass customization processes in the near future.

In summary, all the major computer companies (including Compaq and Gateway) have moved their business to the Internet with agile infrastructures in place (i.e., including agile manufacturing, agile product development, usage of agile software and supply chain networks), in order to economically optimize their respective mass customization processes. Also, they are focused on maximizing the use of the Internet and developing new strategies to expand business via the Internet in order to improve their financial bottom line.

The computer industry closely approaches true mass customization, but is limited because of its incapability to customize exactly to each customer's desire due to (1) limitations in product hardware design, (2) human-computer interface issues including ergonomic factors with product hardware and software, i.e., each individual makes use of each computer hardware configuration and software program differently, and (3) technological limitations, i.e., what the customer desires isn't always technologically feasible.

2.2 **Industry #2 – Automobile Industry**

Mass customization, in its purest form, is not practical in today's world in the automobile industry due to the complex design and the number of parts in vehicles (an average automobile has approximately 3,000 parts) (Simison, 2000). An automobile is much more complex and difficult to assemble than a computer (which has on average maybe 30 parts). The assembly time is also much greater for 3,000 parts than 30 parts. Painting vehicles is another time-intensive process that is not an issue when manufacturing computers. Vehicles are shipped by railroad and in increasing numbers by truck (Simison, 2000). Shipping a 2-ton vehicle via Federal Express is not possible, whereas a 20-pound computer can be shipped easily via Federal Express in two days. Therefore, true mass customization in the automobile industry is not possible. Moreover, the customers expect rapid delivery of customized products; therefore, the industry has been forced to find a way to satisfy ever-demanding customers in order to be profitable. The industry is hopeful about several strategies, which are variants of mass customization for economic savings.

In this section, three automobile companies are examined: Volkswagen, because it has been one of the most successful large automobile companies that has been closest to approaching "true" mass customization, and General Motors and FORD, because they have been long-standing U.S. automobile manufacturers that are currently implementing bold new mass customization strategies and have heavily influenced the U.S. economy for the past century.

2.2.1 Volkswagen

Volkswagen started out as a branch of Porsche in the mid-1930's, but gained recognition as the company that produced the famous "Beetle," a simple low cost car. After the second world war, the Beetle (or "Bug") design was continually refined and was finally introduced to the international market. Thus, Volkswagen grew significantly and expanded its product line in the 1960's and 1970's to become a successful car company. Volkswagen also used the same mass production techniques that other large car companies used during this time period until they were forced to customize vehicles to stay alive in the quickly changing automobile industry.

Volkswagen's story of moving to their version of mass customization is an interesting one, which has required many changes, but has ultimately been very successful. With its expanding product line, they modularized components in the early 80's in order to decrease manufacturing costs. This led them to create other opportunities to optimize their overall mass customization process by identifying problems with their design and manufacturing processes as well as their supply chain network.

One main problem was Volkswagen's vehicle distribution network. Since Volkswagen

vehicles sold in the U.S. are manufactured internationally in two locations (Mexico and Germany), they are first shipped to one of five U.S. distribution centers, and then ultimately to the dealerships by truck. This resulted in slow vehicle delivery times and high distribution and inventory costs. Therefore, Volkswagen hired an outside corporation, Production-Model Corporation (Pro-Model), to help improve their overall distribution network by (1) improving customer service, vehicle delivery and market responsiveness, and (2) reducing total distribution and inventory holding costs (Karabakal, 1997). In other words, Volkswagen focused on developing an agile supply chain.

Pro-Model was able to develop a computer model that included fundamental performance elements within Volkswagen's existing supply chain, i.e., inventory control policies of quantity and mix at dealers, truck loads, demand seasonality. This model also included stochastic elements such as customer demand, customer choice, and transportation delays (Karabakal, 1997). Pro-Model concluded that in order for Volkswagen to improve vehicle flow through its supply chain in a cost-effective manner, it needed to establish more distribution centers closer to metropolitan markets. This would then allow for an improved delivery system, cheaper truck and rail routes (hence, cheaper transportation costs), shortened delivery lead times and increased chances of satisfying a customer's first choice vehicle via the combination of the dealer and distribution center (Karabakal, 1997).

In order to increase the agility of its distribution centers, Volkswagen developed two types of distribution facilities (Type I and Type II) based upon Pro-Model's recommendations. A Type I facility was a small-scale and relatively cheap facility; a

Type II facility, however, was larger, and operating expenses were higher. Based upon other recommendations made by Pro-Model and considering economies of scale, Volkswagen installed Type I or Type II facilities near many high-demand areas around the U.S. This increased the agility of Volkswagen's distribution capabilities, which ultimately enabled Volkswagen to increase its vehicle flow through its supply chain and thus reduce costs (hence, increasing the agility of its supply chain).

After having developed this agile supply chain network, Volkswagen has seen positive results, i.e., its overall distribution costs have significantly been reduced. Volkswagen projects over $20 million a year in savings in transportation costs from its newly developed agile supply chain. It has also seen significant increase in customer and dealer satisfaction, as a result of an improved vehicle delivery system and an ability to react more quickly to market changes (Karabakal, 1997).

In addition, Volkswagen improved its manufacturing agility. It has two main international manufacturing locations as mentioned previously. Volkswagen faced difficulty with manufacturing facilities in Germany due to the existence of strong unions there. Ultimately, Volkswagen moved production of some products to Bratislava in the Czech Republic, in order to cut costs and increase flexibility. In Germany, Volkswagen forced all production to be driven by just-in-time methods, thereby reducing storage costs and delivery times. Also, they implemented self-assessment programs, which reduced the need for quality control supervision and subsequent corrective work. Peter Hatz, the head of human resources at Volkswagen, is concerned about making its German plants more profitable, due to some of the challenges Volkswagen has faced there. Currently, Volkswagen is testing a radically new manufacturing plant, that involves a plan called the

"5000 by 5000 model," with the goal of keeping unions happy and simultaneously being able to launch new products at significantly lower costs (www.germanyspellsbusiness.com, 2000). These challenges aside, Volkswagen has been successful in increasing the agility of its manufacturing facilities in order to enhance its overall mass customization strategy.

Volkswagen has also concentrated on making its product design process more agile in order to optimize its overall mass customization strategy. Its strategy is to use existing platforms, which are cheaper and faster than starting all over. They then make improvements to existing platforms, reducing the overall time from initial product design to ultimate final production to 36 months (Volkswagen, 2001).

However, Volkswagen has done much more to optimize its overall mass customization strategy in order to improve customer satisfaction and make a profit. Volkswagen has developed a web page, at www.volkswagen.com (see Appendix), which allows customers to adaptively customize their choice of automobile, consider prices before purchase, and track an actual customized order. This Internet customization capability was made possible by the previous development of Volkswagen's overall agility in its design, manufacturing and supply chain processes.

In addition, Volkswagen has used unique marketing techniques with innovative products to attract customers via the Internet. In 1998, Volkswagen introduced "The New Beetle" via the Internet, which has been very successful. Currently, "The New Beetle," is rated as a "Best Buy" for compact cars, according to www.consumerguide.com, a reliable car consumer guide agency. Also, Volkswagen launched a separate new special web site in June of 1999 at www.Turbonium.com, in

order to introduce a new product called “The New Beetle 1.8T” (a high powered version of The New Beetle). As Dave Huyett, Volkswagen’s director of marketing, stated, “The new turbo version (the 1.8T) adds an element of pure power to this remarkable original and modern design (of The New Beetle), and we injected this same power, or Turbo, into the advertising” (Volkswagen of America, Inc., 2000). The web site, at www.Turbonium.com, features high-animation, music, vehicle information, and other elements, which are extremely impressive. According to company officials, “Volkswagen will continually add fresh, new content to encourage visitors to return to the website” (www.digitrends.com, 1999). Also, Volkswagen decided to offer a “Limited Color Edition New Beetles” series, available only through the Internet in May of 2001 (Volkswagen of America, Inc., 2001). Other models, such as the Volkswagen Jetta, have become very popular vehicles in Europe and in the last 3-4 years also in the U.S. (Bartusek, 2000). In other words, Volkswagen has been successful in improving its overall mass customization strategy by integrating smart marketing techniques with impressive new products via the Internet.

Thus, by increasing its overall agility, using the Internet to enable customers to adaptively customize products, and by using smart marketing techniques, Volkswagen has prepared itself for a successful future. For example, Volkswagen’s overall sales, for July of this year, have been the best the company has seen in 28 years (Volkswagen of America, Inc., 2001).

2.2.2 General Motors

General Motors originated from the Olds Motor Vehicle Company, Inc., at the beginning of the 20th century. In 1899, Olds Motor Vehicle and another company, Olds Gasoline Engine Works, formed Olds Motor Works, which, in the same year, built its first factory for automobile manufacture in the United States, in Detroit, Michigan. The car produced on this manufacturing line was named the Oldsmobile, and it was the first American car to be manufactured in quantity. Eventually, over the next twenty years (1900-1920), three other companies, namely, The Cadillac Automobile Company, The Buick Motor Company, and the Chevrolet Company, merged with Olds Motor Works to form the General Motors Corporation, as it is recognized today (www.gm.com/company/corp_info/history/gmhis1900.htm).

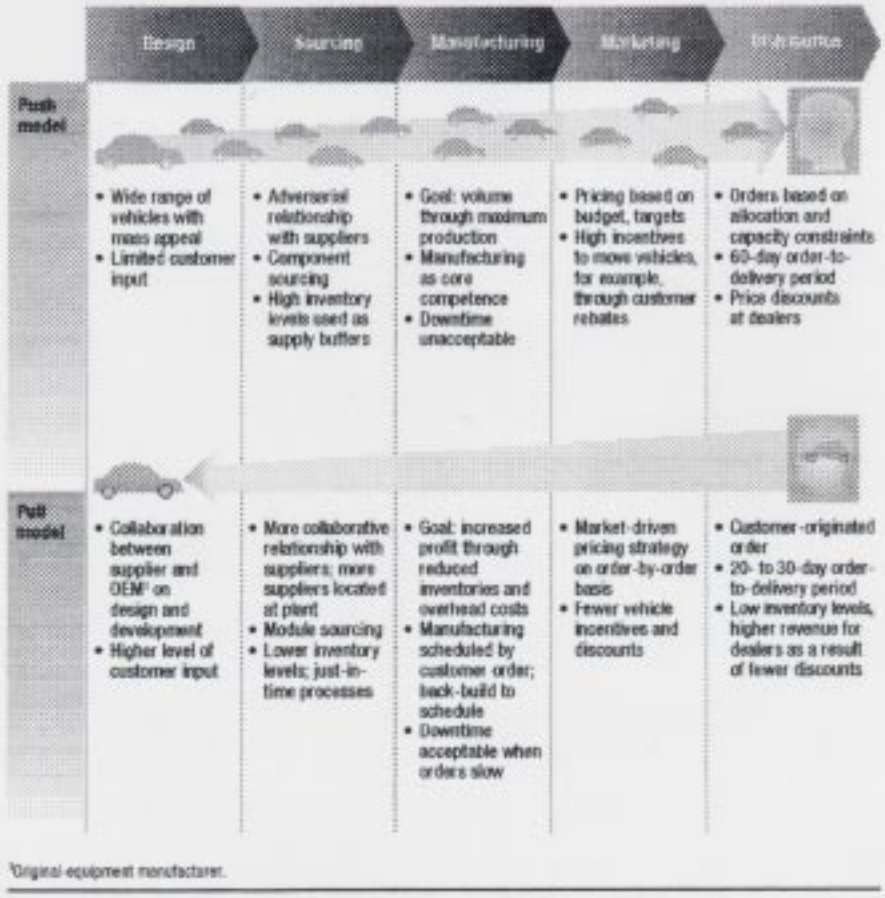
Eventually, in the 1950's, 1960's, and 1970's, using a mass production system, General Motors became a household name in the United States by building a solid reputation for high quality vehicles at reasonable prices. Then, in 1980, GM announced, "that it will spend $40 billion from 1980 through 1984 in a worldwide program to redesign its vehicles and modernize its assembly plants," due to increased competition in the marketplace (i.e., modularize components and increase the flexibility of its manufacturing facilities with hi-technology, while still using a built-to-stock or mass production approach). In the same time frame, GM became a recognized quality car manufacturer in the international marketplace through several joint ventures with international companies such as Isuzu, Toyota, and Volvo. Eventually, in the mid-nineties, GM began to rethink its car design and manufacturing processes once again, due to increased competitive pressures within the industry.

(www.gm.com/company/corp_info/history/gmhis1900.htm). This led to General Motor's current plan to compete in today's automobile industry.

"A Built-to-Order system is the most significant change in the auto industry that will happen over the next five years," stated Ralph Szygenda, GM's chief information officer, in June 2000 (Hyde, 2000). As a result, in order to keep up with the competition, General Motors is currently planning to transform itself from a Built-to-Stock system (the current system) to a "Built-To-Order" (BTO) system. As GM CEO G. Richard Wagoner Jr. says, "This model (a BTO system) gets you closer to the customer, and if we understand exactly what's happening in the market when it's happening, we're better off" (Hyde, 2000). Implementing a BTO system involves going from a push manufacturing system to a pull manufacturing system; however, this transformation requires many challenging operational and organizational changes in the auto industry value chain (Agrawal, et al., 2001). See Exhibit 1 on page 27.

EXHIBIT 1

The automotive value chain: When push comes to pull



[1]Original-equipment manufacturer.

GM predicts that 70% of its customers would take advantage of its new individual customized vehicle ordering system, i.e., the true BTO system, once fully implemented (Simison, 2000). Also, GM predicts a 20 billion dollar savings from parts and unsold cars sitting in inventories after successful implementation of its BTO system (Simison, 2000). "We know from our surveys that a good percentage of people who buy vehicles from the dealer inventory position (with the current built-to-stock system) walk away and three months after the purchase are dissatisfied because they didn't get something they really wanted," states Harold Kutner, GM's director of worldwide purchasing (Hyde,

2000). This data collection from surveys further supports the decision of GM to transfer to a BTO system, which would enable customers to get exactly what they want. Kutner also claims, "such a system (BTO) could cut new vehicle inventories by half, among other benefits" (Hyde, 2000).

However, GM has recognized the challenges in successful implementation of a BTO system and thus are focusing on what they are calling a "virtual BTO" system in the short-term. It is defined as the process that "enhances the customer's ability to locate a suitable existing car to order" and is being implemented on the Internet (Agrawal, et al., 2001). GM has launched a program called "GM Buy Power" at www.GMBuyPower.com (see Appendix), which enables its customers "to research and locate existing cars with the features they desire or to get cars by special order" (Agrawal et al., 2001). General Motors is also planning to launch "Auto-Centric," which would link a locate/build-to-order application to a web retailer like Autobytel.com (Agrawal, et al., 2001). This, in effect, would increase the ability of customers to find their desired vehicle at the nearest dealer.

In addition, strategically planning for the long-term, GM has launched a 3-year plan to reinvent how they design, build, and ship cars (Simison, 2000), i.e., a plan to actually implement a true BTO system. This plan, if successfully implemented, would allow people to custom-order cars online and have their vehicles appear at their doorstep within four days (Simison, 2000). See Figure 2 on page 29.

	1999	2003
Lead time, order, manufacture	10 days (minimum)	3 days
Shipping time, normal	11 days (average)	1-8 days
Shipping time, premium		1-4 days
Elapsed time, order delivery	Up to 8 weeks	4-11 days

Figure 2: Making GM Internet Ready: Key changes GM has to make so you can order a new car online, equipped just the way you want it (Credit: Staff Reporter of The Wall Street Journal al.)

Harold Kutner is the man in charge of implementing this daunting makeover at GM and is focused on an improved understanding of what the customer wants. He hopes to accomplish this by capturing information on-line when consumers adaptively customize vehicles on-line (thereby using a customer integration strategy), and hence GM designers can simplify part procurement and assembly and reduce costs (Simison, 2000). This would increase the agility of the design and manufacturing processes at GM, which is necessary in implementing any successful BTO system.

Kutner also claims that in order for the system to work for GM, "suppliers must be close enough to assembly plants to ship parts within a few hours of an order. We must have a more precise way of tracking vehicles through the process" (Hyde, 2000). Kutner is basically stating that GM needs to develop an agile supply chain network. An agile supply chain network is required to successfully implement a BTO system; however, GM has not specifically outlined its plans to create this agile supply chain network.

2.2.3 FORD Motor Company

"The history of FORD Motor Company is, in many ways, the quintessential story of the American dream. Armed with big ideas and little cash, a man named Henry Ford set out in 1903 to make the automobile accessible to every American. Almost a hundred years later, his company has become the world's biggest producer of trucks and the second biggest producer of cars and trucks combined" (http://www.ford.com/servlet/ecmcs/ford/index.jsp?SECTION=ourCompany&LEVEL2=heritage).

From 1900-1930, the Model T and the Model A became household names for quality cars from FORD Motor Company (using mass production). By 1959, FORD had produced its 50 millionth vehicle and as early as 1967, FORD had developed an international branch called FORD of Europe. In the seventies, FORD expanded internationally via joint ventures opening up manufacturing facilities in Japan, Spain, and Taiwan. In 1987, electronic communication allowed FORD Motor Company to launch a computer-based system known as the Worldwide Engineering Release System (WERS) to link manufacturing and engineering groups in FORD locations worldwide. "The emerging WERS technology established a global network -- not only with employees, but also with suppliers, joint venture partners, academic and government researchers, and customers around the globe," thus developing an agile supply chain network. Also, in 1997, the company created Visteon, a wholly owned enterprise of FORD Motor Company to explore and expand the market for components of their products around the world (http://www.ford.com/servlet/ecmcs/ford/index.jsp?SECTION=ourCompany&LEVEL2).

Changes in competition within the industry, have constantly caused FORD to rethink its manufacturing and product design strategies, similar to General Motors. Currently, FORD Motor Company is also developing a "Built-To-Order" (BTO) system for mass customization in order to remain profitable in today's automobile industry. However, as mentioned previously, this transformation requires many challenging operational and organizational changes in the auto industry value chain.

Since there are many challenges when implementing a BTO system, FORD is also focusing on a "virtual BTO" system in the short-term (similar to General Motors) via the Internet. FORD launched "FORD Direct" in December of 2000 in nine states in the U.S. at www.FordDirect.com (see Appendix), which should be available nationwide to customers by the end of 2001. It gives customers the ability to search for vehicles in dealers' inventories, and it will soon be able to provide information about vehicles on the production line and those currently en-route to the dealer (Agrawal, et al., 2001). They accomplished this by forming a partnership with Microsoft last year in order to help facilitate the design and introduction of the web pages at www.FordDirect.com (Valencia, M., 2000). This program provides higher variety for customers (Massenproduktion, 2000).

In addition, because the Internet has blurred traditional boundaries between wholesale, manufacturing and supply, FORD has hired an outside company to have a "portal", which is a system that assembles and summarizes all types of information and services FORD has in order to help management stay on top of strategic decisions, which in today's world are focused solely on satisfying the customer. "Thus, by using this system, they are able to stay on top of customer demands and expectations, and thus

improve their overall mass customization strategy" (www.plumtree.com, 2001).

2.2.4 General Trends in the Automobile Industry

The automobile industry is currently gearing up for what is now being called "e-customization," which is basically a form of mass customization via the Internet (Schwartz, 2001). The key to "e-customization" is that all divisions and customers of an automobile company can access information in real time. This will potentially decrease the time to market of products, as well as reduce the wasted efforts on projects changed by other divisions. This "e-customization" is going to enable other industries and their customers to also share information instantaneously, which is going to further increase competition in their corresponding industries.

Time to market is critical in the automobile industry, and being able to instantaneously see trends in the marketplace via the Internet allows a company to react quicker to market changes. A quicker reaction time is viewed by customers as improved customer service. This real-time communication process, enabled by the Internet, is being expanded across all parts and divisions of the U.S. automobile companies, in order to ultimately improve customer satisfaction while increasing profits (Schwartz, 2001). This quicker reaction time is helpful to overall mass customization, i.e., learning how to give customers what they want exactly when they want it (Duray and Milligan, 1999).

Thus, automobile companies are developing their own strategies for "e-customization". One such strategy is the built-to-order (BTO) system being developed by FORD and GM. After eventual successful implementation of a BTO system, an automobile company expects significantly lower supply chain costs (a BTO system

would essentially have a pull system meaning drastic reduction in finished goods and in component inventories for both dealers and suppliers). Analysts in the automobile industry predict that up to 70 percent of the capital lost due to the current push system could be saved, thus saving the whole automobile industry a projected 65-80 billion dollars annually (Agrawal, et al., 2001). Each individual car company would therefore obviously like to be the leader in the industry with a successful BTO system in order to capitalize on this savings potential; however, the challenges are significant for the successful implementation of a BTO system. These challenges involve changing management paradigms, operational changes, design and supply changes, which have proven to be challenging for several companies (Agrawal, et al., 2001).

For example, with "design changes", it was believed that modularizing, i.e., building cars from mixes of modules instead of from thousands of parts, would reduce inventory redundancy and waste within the supply chain. However, the modularity of DaimlerChrysler's "Smart-car" and Volkswagen's "Resende" truck, for example, has introduced problems in productivity and quality in their respective manufacturing plants (Agrawal, et al., 2001). Another significant point in the "supply changes" category is that factories and suppliers would have to be wired together via the Internet and delivery times cut in half in order to implement a successful BTO system (Simison, 2000). Hence, successful implementation of a BTO system in the automobile industry will not be easy. However, the current "virtual BTO systems" via the Internet seem to be keeping customers satisfied – at least for now.

The final question becomes whether or not customers will buy cars with an actual BTO system. Surveys conducted by J.D. Power and Associates in 2000 concluded that

17% of U.S. car buyers would purchase a BTO vehicle if it was the same price as before and if they didn't have to wait more than 8 weeks for delivery (Agrawal, et al., 2001). However, Agrawal and his co-authors (2001) conclude that virtual BTO is the better option, because the true BTO system is just too difficult to implement from a practical standpoint in the automobile industry due to its many challenges. However, top executives at Volkswagen, General Motors, and FORD clearly have an opposing view, which is supported by their current strategies to implement true BTO systems.

In summary, the automobile industry has increased its focus on the following elements of its infrastructures in order to economically mass customize:

(1) developed agile infrastructures, including agile manufacturing facilities, agile product design capabilities, and agile supply chain networks,

(2) focused on using the Internet to allow customers to adaptively customize vehicles and purchase them via the Internet

(3) aggressively used the Internet as a marketing tool to introduce new products, and to expand services, such as technical support and purchase decision making

(4) successfully used computers and new hi-technology to improve overall agility, and quality and safety of products.

The automobile industry is unable to truly mass customize due to limitations involving: (1) the costs of inventory involved in keeping numerous different parts at a particular manufacturing location for each vehicle which has approximately 3000 parts, (2) the costs of shipping multiple parts to a particular location for each vehicle, and (3) costs involved with manufacturing to produce a truly customized product for each customer.

2.3 **Industry #3 - Retail Industry**

The final industry studied is the retail industry. In this paper, the retail industry includes only those companies that produce clothing and apparel. It does not include companies with products such as toys, dolls, games, or high performance bicycles whose designs are much more complex.

Three companies are analyzed: Levi Strauss & Company, because it is currently implementing bold new mass customization strategies and has been a major retailer of clothing in U.S. industry for many years; AmericanFit, because it implementing aggressive Internet mass customization techniques, and Nike, because it has high variety and has had to shift to mass customization to increase market share.

2.3.1 Levi Strauss & Company

Levi Strauss & Company was founded in 1853 by Bavarian immigrant Levi Strauss. In 1873, Levi Strauss and Nevada tailor Jacob Davis patented the process of putting rivets in pants for strength, and the world's first jeans — Levi's® jeans — were born. The company is privately held by descendants of the family of Levi Strauss. Today, the Levi's® trademark is one of the most recognized trademarks in the world and is registered in more than 160 countries. Levi's is a worldwide corporation organized into three geographic divisions:

(1) Levi Strauss, the Americas, based in the San Francisco headquarters

(2) Levi Strauss Europe, Middle East and Africa, based in Brussels

(3) Asia Pacific Division, based in Singapore

There is no other company with a comparable global presence in the jeans and casual pants markets in the world today. Levi's market-leading apparel products are sold under the Levi's®, Dockers® and Slates® brands.

Levi Strauss & Company recently created a product called Personal Pair jeans that can be tailored to each individual customer by waist size, hips, rise, and inseam (charging a $10 premium for each customer). Levi Strauss made this possible by buying a patented software technology from a company called Custom Technology Corp. of Newton, MA; the technology electronically chooses a stock inventory and then transmits the custom order to the respective Levi's factory allowing for improved manufacturing flexibility during production. Time from placement of the custom order to home delivery is less than two weeks. As a result of this Personal Pair jeans product, Levi Strauss has increased the number of manufacturable sizes from 40 to 4,000, and also 5 additional options on color. Thus, Levi Strauss has been able to increase its and manufacturing agility as a result of this new technology and new product (www.LeviStrauss.com). More importantly, this represents an example of how a long-lived design such as classic Levi jeans has been able to remain stable during drastic market changes in demand using mass customization. A successful mass customization process is inherently flexible and can react quickly to market changes without increasing costs significantly. In this case, Levi Strauss used an existing long-lived product, offered improved variety in a sense by customizing, and thus has increased the longevity of its product (Sanderson and Uzumeri, 1997).

In addition, Levi Strauss has focused on increasing the agility of its supply chain. This effort has been enabled by the use of TIBCO Software, which provides real-time

infrastructure software for e-business. The software has enabled Levi Strauss to automate supply chain processes by creating an integrated network of applications, databases and information throughout the company. Specifically, the software allows Levi Strauss' Enterprise Resource Planning (ERP) System to utilize the best technologies from Baan, Oracle, Manugistics and Hewlett-Packard, while the technology in the TIBCO software acts as an integration infrastructure between the diverse applications. Integration of a supply chain is a key part in ultimately developing an agile supply chain. This software is currently being used in the Europe, Middle East & Africa (EMEA) markets. Levi Strauss' EMEA network handles 30 million order lines annually (www.tibco.com).

As John Serrato, vice president of IT for Levi Strauss states, "TIBCO's real-time infrastructure has enabled the automation of our core business processes as an integrated European entity. This is essential to our success in the future. We are now in a position to extend our business processes along the length of the supply chain to include our suppliers, customers, distributors and business partners" (www.tibco.com). Thus, Levi Strauss has developed an agile supply chain process for one of its three main worldwide markets. Levi Strauss plans to use TIBCO software in the other two major Levi Strauss market segments in the near future, thus further improving the agility of the supply chain for Levi Strauss worldwide.

Finally, as a result of the increase in agility of its overall infrastructure, Levi Strauss has been able to develop a web page at www.levi.com (see Appendix), which allows customers to adaptively customize jeans and other clothing on-line. Initially, this web page was unsuccessful and shutdown because it restricted retailers from selling Levi

Strauss products on-line, and so they eventually promoted their own product lines. This, in turn, eventually caused decreased sales for Levi Strauss; however, the web page is back on-line with a new approach, which has integrated retailers in some of Levi Strauss' sales volume (www.infoworld.com).

2.3.2 American Fit Corporation

American Fit Corporation, a relatively new clothes company based in New York City, is currently using its web pages to advertise and promote their customizable clothing line throughout the U.S., which includes both men and women fashion clothing, such as khaki pants, jeans, shirts, skirts, etc. Their motto is "Don't throw a fit, get your clothes custom fit." They are currently advertising that with their system known as "Virtual Taylor", you (as a customer) can "design and customize clothing made just for you" on their web page at www.americanfit.com (see Appendix). The web page offers 10 different styles of clothing, then a choice of a myriad of fabrics and colors, and then 3 options. Option #1 is selecting a regular size and then American Fit offers to alter the waste and inseam. Option #2 allows you to enter your body measurements so that American Fit can fully customize your order. Option #3 allows you to choose your most desired pattern (with customized features) based on your individual previous orders at www.americanfit.com. In other words, they offer the customer a choice of a standard product with some adjustments, i.e., an adaptive customization strategy (option #1), a fully customized product (option #2), and build a database of customer information, i.e., implement a customer integration strategy in the form of a customer option (option #3) (www.americanfit.com, 2001).

The web page not only allows customers to purchase a customized piece of clothing on-line, but also allows them to preview prices before the purchase and track their order after the purchase. The web page is impressive and it gives customers a very simple set of options while simultaneously allowing for extremely high product variety.

Of course, American Fit has only been able to implement its web-based strategy approach due to its agile manufacturing systems. Its manufacturing system uses breakthrough technologies in pattern making software, which enable a dramatic increase in the agility of garment manufacturing processes. American Fit "creates new garment patterns with specific body measurements without altering the look of the garment and preserving the fit of the style" (Tamir, J., 2000). Then, the customer's individual style preferences are integrated to the patterns and the fabric is individually cut by a laser cutter. Hence, each order is individually manufactured, resulting in the "perfect FIT" (www.seditious.com, 2000). American Fit has a 100% satisfaction guaranteed policy and an average delivery time of one week to the customer from the time of the initial order (www.jonastamir@americanfit.com, 2001). Thus, the agile infrastructure, enabled by breakthrough technologies in pattern making software, makes it possible for American Fit to pursue an aggressive web-based mass customization strategy.

2.3.3 Nike

Nike was founded by Phil Knight in the 1970's and by 1979, Nike was #1 in sport shoe sales in the Unites States. Nike's next big break in the 1980's when basketball superstar Micheal Jordan signed with Nike to wear Nike shoes during NBA games (www.nike.com). Nike continued to grow, and today it is a well-known shoe company

that has about 1000 shoe styles with 100 new styles being introduced annually. With this large amount of product variety, it is very important that Nike keeps its cost structure low while still providing high variety for customers. It has accomplished this in several ways. Over the years, Nike has moved nearly all of its manufacturing facilities to South Korea, Taiwan, and other locations in the Far East to contract manufacturers for its annual production of about 90 million shoes.

These contract manufacturers have been able to develop specialized production for the core of Nike's business, the sports shoe. Formally, shoe designs were sent to the contract manufacturers via a CAD/CAM system six months ahead of production. This process allowed Nike to guarantee delivery times and contractors to avoid excess inventories. However, in the last several years, Nike has faced a reduced demand in the sports shoe and also greater market uncertainty. Thus, they have been forced to change their strategy and that has included developing new product families for their shoes in an effort to mass customize. Their contract manufacturers have made the task simpler and less risky for Nike because they are already specialized, i.e., Nike is not vertically integrated from a manufacturing standpoint and therefore it isn't capitally invested in its own production facilities. In its efforts to mass customize, it has also developed new relationships with contractors in China, which are even cheaper than those in South Korea and Taiwan. Thus, Nike has been able to develop an agile manufacturing system, i.e., one that "expands a company's manufacturing domain by exploiting the production capabilities of a network of manufacturing facilities" (Sanderson and Uzumeri, 1997).

Before using the Internet as a tool to sell, Nike recognized the increased importance of the role of logistics in a web-based sales strategy. A web-based strategy requires that

very small quantities (e.g., 1 pair of shoes) be shipped to hundreds of thousands of individual customers. Major notable retailers such as Amazon.com have had trouble doing this successfully (Burris, et al., 2001). In addition, another logistical issue arises with the inevitable return of a product by the customer to the manufacturer for replacement. Thus, a company must be ready to efficiently return a new product to the customer. Nike understood these logistical issues and has been successful in integrating them with its web-based strategy (Burris, et al., 2001).

These infrastructure changes have allowed Nike to offer mass customization to their customers via the Internet. Nike currently has a web page, www.nike.com (see Appendix), that allows a customer to choose from a myriad (meaning literally hundreds) of standard models in different shoe categories and customize their own shoe through a variety of customized options (e.g., color, size, material, etc.). Nike also allows users to access everything on the web page in several languages, by specific country, or by general shoe category (www.nike.com, 2001). Nike is also collecting data via this web page and thus building a better information base of individual customers, i.e., using a customer integration strategy. This also allows Nike to see trends or patterns of customers' changing needs more quickly and can therefore react more quickly because of its agile infrastructure in order to stay profitable.

Simply put, "Successful mass customizers establish an information cycle interconnecting all steps of the mass customization process and integrating their customers and suppliers alike" (Massenproduktion, 2000). Nike has accomplished this with the Internet and an agile infrastructure.

2.3.4 Other Examples in the Retail Industry

Interactive Custom Clothes, in Connecticut, sells jeans over the Internet, allowing customers to specify hip size, leg and seat room, fabric, color, thread accents, leg silhouette, fly design, pocket style, buttons, rivets and even label. The pants are produced at a manufacturing plant in New York City which is very flexible (Cox and Alm, 1998). Digitoe, a shoe company in Washington, uses a scanner to measure every millimeter of customers' feet for custom-made shoes. Then with the help of a computer system, the scanned images (one image of each foot of course!) are digitized to build a 3-D model of a pair of shoes, which can then be manufactured according to any style and hence ultimately "molded for the perfect fit." From placement of the order, it takes only 3-4 weeks for delivery (Cox and Alm, 1998).

Benetton Inc., a popular clothes manufacturer based in New York City, successfully applied postponement to drastically increase manufacturing agility and ultimately decrease costs and increase sales. Sweaters are among the items of clothing that Benetton sells. Originally, the sweaters were dyed and cut to size accordingly during the manufacturing process. Benetton adjusted its manufacturing system, which produced the sweaters without the dye. Then, after a customer order came in requesting a certain color for a certain size, a sweater of that size was promptly pulled from inventory and dyed to the specific color via a quick dyeing process. This increased the agility of the production capability, and thus Benetton could react more quickly to customer orders and at the same time decrease costs (Lee and Tang, 1993). Benetton has also expanded to the Internet with a web page that offers adaptive customization for most of its clothing (www.benetton.com).

LandsEnd, another popular clothes company located in Dodgeville, Wisconsin, has a web page www.landsend.com, that allows adaptive customization of its products on-line, which LandEnd calls “LandEnd’s Custom.” The web page makes it possible to custom design shirts and pants in almost any way, shape or form. It has a virtual on-line model (an image of a person), which the customer can change according to their preferences, enabling the customer to view the clothing they have chosen.

Shirt Creations, a clothing company based in New York City, has developed a web page www.ShirtCreations.com, that allows customers to adaptively customize shirts online. The web page allows customers to customize almost any kind of shirt imaginable.

2.3.5 General Trends in the Retail Industry

Retail industries have:

(1) aggressively sought to improve the agility of their infrastructures, specifically, the agility of their manufacturing systems, product design approaches, and supply chain networks.

(2) used advanced technology wherever possible to increase infrastructure agility and reduce costs.

(3) used customer integration strategies via the Internet in order to get to know their customers better. This strategy has also allowed them to more quickly detect changes in customer preferences and thus, via their agile infrastructures, to more rapidly react to those customer changes with altered product variety.

(4) made use of the Internet to allow customers to customize their own products with web

pages that offer high variety.

The retail industry cannot truly mass customize because of product limitations. Although Digitoe does truly mass customize with its scanned images of each foot for customized shoes, this concept is not applicable or practical for all clothing.

3. General Trends Across All Industries Discussed

There are specific trends that have been used repeatedly across the computer, automobile, and retail industries and have proven to be effective for mass customization. These trends and other observations are summarized next, and differences between the industries are also discussed. Then in Section 3.2, future directions for mass customization are discussed.

3.1 General Trends and Observations

Companies are always searching for better ways to satisfy customers. This involves learning how to get to know customers very well in order to provide sufficient product variety for them while economically mass customizing.

In general, companies are **using advanced technology** to help in their efforts to mass customize their products, i.e., sophisticated software and computer systems, that track customer orders and enhance product quality and safety. For example, GM and FORD are using virtual BTO systems that utilize highly sophisticated software to mass customize economically.

Companies are also **aggressively developing agile infrastructures** including the development of agile manufacturing systems, agile design process capabilities and agile

supply chain networks, to enable quick and cost-efficient product and production changes based on changes in customer preferences and demand.

In order to develop these agile infrastructures, many companies have:

(1) developed new processes; for example, Dell designed “Premier Pages,” which was a web-site focusing on just one type of customer to improve customer service.

(2) invented new technologies; for example, Volkswagen hired an outside corporation to develop software to analyze Volkswagen’s supply chain (including all elements of the supply chain) in order to improve vehicle flow through its supply chain in a cost-effective manner.

(3) developed innovative new techniques; for example, Volkswagen used a unique marketing technique, whereby it developed a separate web-site to introduce a new product. Its web pages have high animation, music, and other elements, which are very effective as a marketing tool.

(4) learned how to better understand the customer by implementing customer integration strategies, thus, companies are strategizing better about future customer expectations; for example, GM has implemented an extremely aggressive 3-year plan that can only be achieved by capturing customer information on-line during the customer order process. GM can then simplify part procurement and assembly and reduce costs.

(5) used new research or products that make manufacturing processes simpler and therefore more agile and less costly; for example, American Fit’s manufacturing system uses breakthrough technologies in pattern making software to achieve a dramatic increase in the agility of garment manufacturing processes.

(6) aggressively mastered technological changes within their respective industry in order

to maximize their overall customization strategy; for example, FORD hired an outside company to create a “portal,” which is a new software system that assembles and summarizes all types of information and services FORD has in order to help management stay on top of strategic decisions, which are focused solely on pleasing the customer.

(7) eliminated tasks for customers whenever possible and economically feasible; for example, Digitoe allows customers to use scanners to measure every millimeter of their feet for custom made shoes, thus eliminating the need for customers to leave their homes in order to receive custom shoes with a “perfect fit.”

(8) used postponement strategies whenever possible to increase agility; for example, DELL reduced its inventory by outsourcing its production up to the latest point for final assembly using a postponement strategy. HP has also used product postponement to successfully mass customize.

(9) maximized the use of product modularity across product platforms and families; for example, DELL modularized components to customize its products and services. IBM and HP also developed modular components through modular product design in order to optimize their respective mass customization strategies.

After having developed an agile infrastructure, many companies are using the Internet as a tool to sell their products as well as a tool for customer service expansion and new product introduction. All of the companies discussed in this paper have begun using the Internet as a tool to sell their products.

Many companies are predicting that the Internet can be used very profitably to mass customize. Thus, companies are aggressively strategizing to discover how they can use the Internet most efficiently to capitalize on their respective overall customization

strategy(s). All of the companies discussed in this paper are aggressively strategizing in order to use the Internet most efficiently to improve their respective mass customization processes.

The successful use of the Internet has already been demonstrated in the computer and retail industries; however, in the automobile industry, it has yet to be shown. According to experts, the computer industry and the retail industry have products that are more amenable to mass customization and Internet-based mass customization; however, the automobile industry has products that are not practical to mass customize via the Internet economically.

While there are many similarities between the companies studied, there are differences among customization strategies between industries. These differences are based primarily upon product differences and are outlined as follows.

(1) The number of parts in a company's product and the company's product design strategy affect a company's particular mass customization strategy. For example, the computer industry has focused on modularization of its components so that it can easily mass customize its products (an average computer has 30 parts and thus modularization can be very cost-effective). In the computer industry, designing modular components has proven to be very effective in reducing manufacturing costs and reducing delivery times to customers, and thus new products are planned using already existing modules and components whenever possible. However, the automobile industry (an average vehicle has 3000 parts) has tried to modularize cost-effectively but has not been as successful. For example, Volkswagen's "Resende" truck had productivity and quality problems on its manufacturing line because of modular components (Agrawal, et al., 2001). It is also

more challenging to modularize different products when each individual product has such a large number of parts. Thus, the automobile's level of focus on modular design of components is not as great as that of the computer industry.

(2) Industries are focusing more on one aspect of agility than another due to product differences. For example, the retail industry is focused more on increasing the agility of its manufacturing systems and the automobile is more focused on increasing the agility of its supply chain network. In the retail industry, manufacturing agility is critical due to the constant demand for high product variety (e.g., Nike has over 1000 products and introduces about 100 new products each year). Through the use of sophisticated software, the retail industry has increased its manufacturing agility and is less focused on the agility of its supply chain. Nevertheless, the agility of the supply chain is still critical in the retail industry. On the other hand, in the automobile industry the efficiency of the supply chain is critical since each vehicle has a large number of parts, and automobile companies must complete orders quickly. However, it is important to note that manufacturing agility is still important to the overall effectiveness of successful mass customization in the automobile industry.

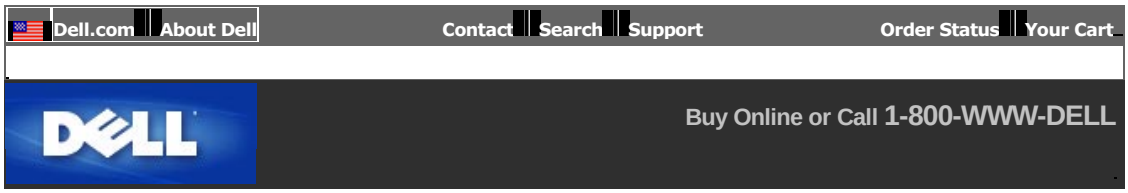
3.2 **Future Directions of Mass Customization**

What does the future hold for mass customization in the business world of the 21st century? Most probably, a wider variety of products will be able to be mass customized due to the inevitable increase in sophistication of technology and how it can ameliorate mass customization. For example, custom-made vitamins already exist that are designed to offer a specific combination of nutrients to supplement one's diet. Is it

possible that colognes could be created by e-shoppers, which combined the scents of jasmine and tobacco that evoke college days?

The introduction of more technologies such as Web TV and online devices for the general consumer market will only hasten the rate of change, bringing more consumer dollars to the online sales channel, thus increasing potential profits for companies who can successfully mass customize via the Internet (Davis, 2001). Fundamentally, however, the Internet represents the most important future element for mass customization. Computing power, pervasive networks, compelling applications, and improved usability are now combined in an electronic infrastructure that is available to the world at large. New applications and ideas will emerge from the connections of these new sophisticated tools. Thus, mass customization will continue to evolve as the level of sophistication of these tools increases.

Appendix:



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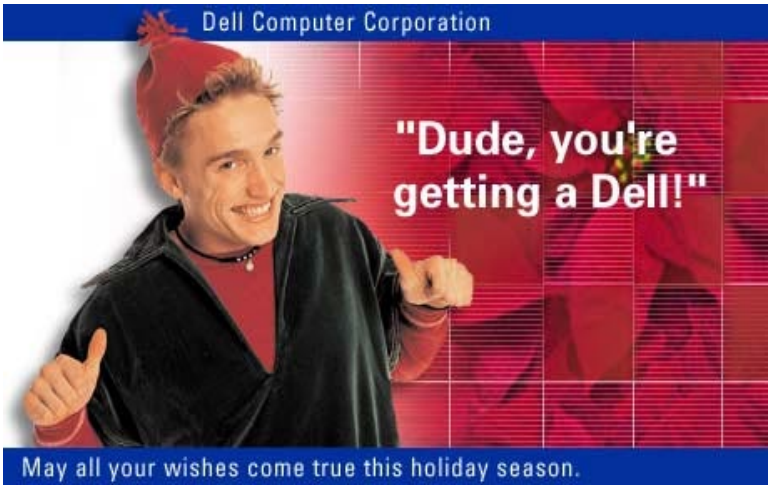

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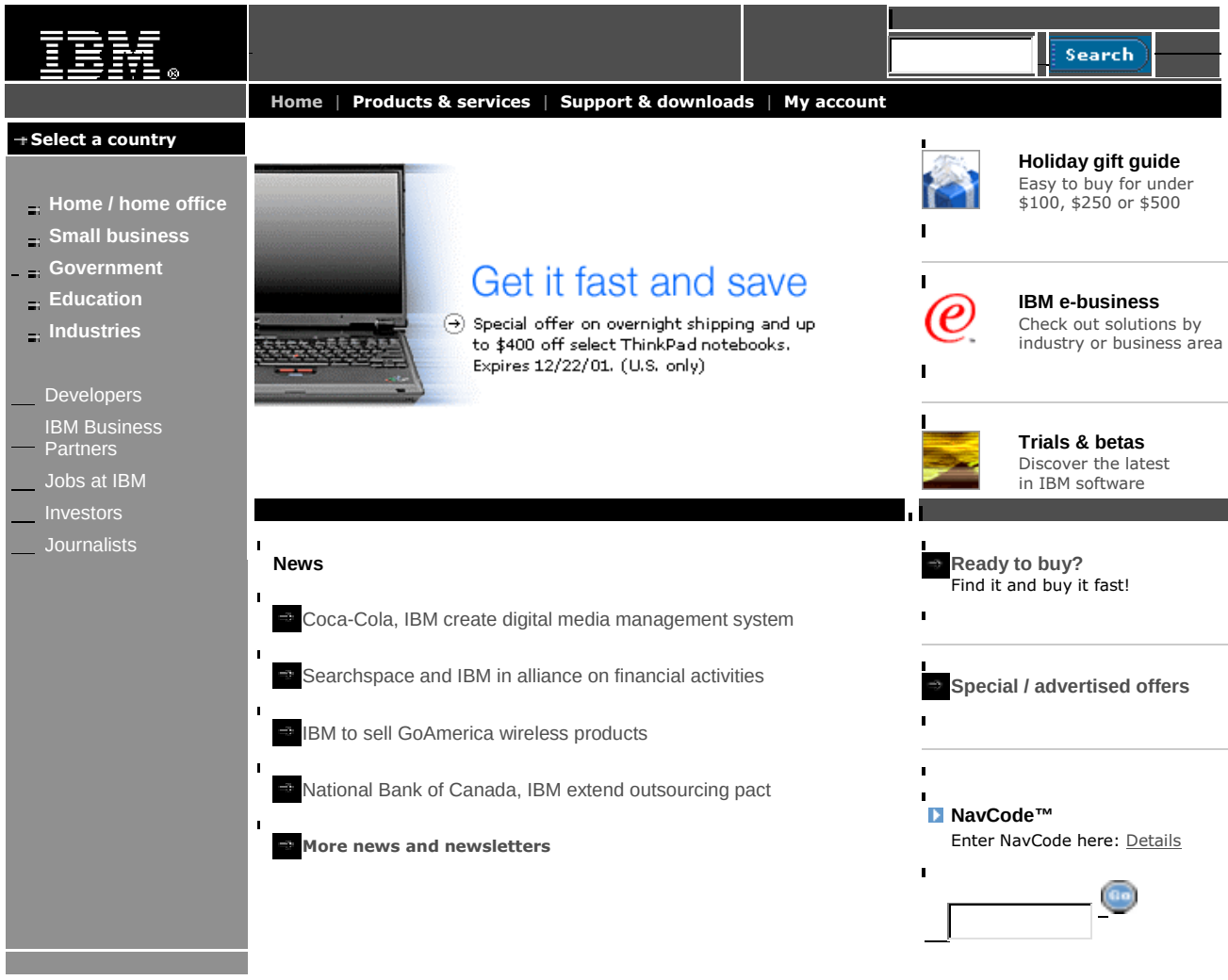
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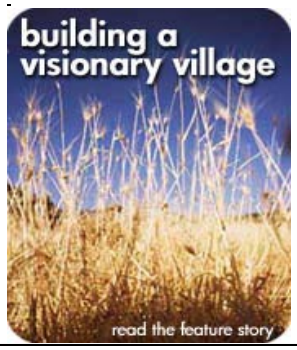

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Step 3: Choose a color.
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Choose your country. U.S.

Choose your VW. Cabrio

CONTINUE

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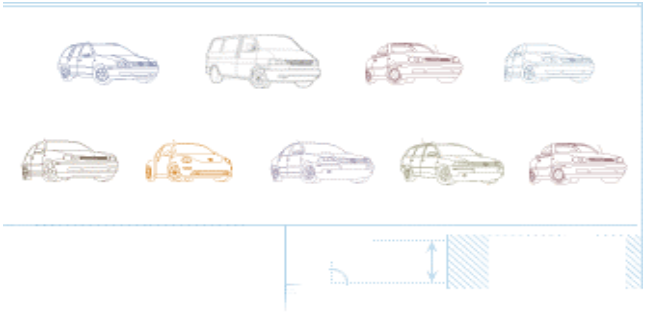

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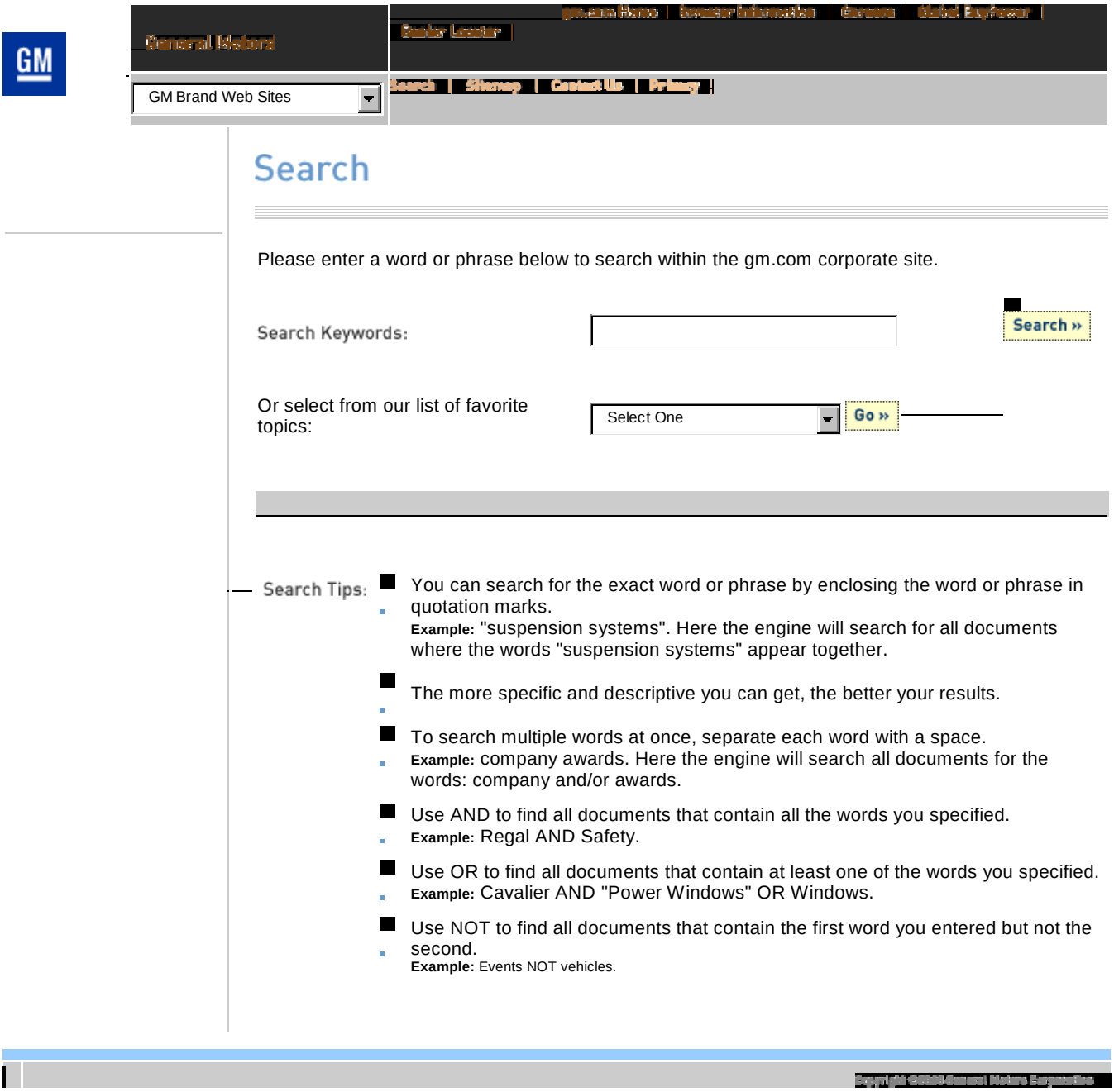

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