

**Customerization in 2030:
A Vision for the Premier Global Manufacturing Enterprise**

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Customerization in 2030: A Vision for the Premier Global Manufacturing Enterprise

ABSTRACT

The primary goal of this report is to present a clear and concise plan for positioning FutureComp Inc. * to be the dominant hi-tech global manufacturing enterprise in 2030. The changing needs of the industrialized world of the 21 century are begging for a paradigm shift in the way we look at the dynamics involved in design, manufacturing, and service. The shift from resource based manufacturing to knowledge based manufacturing systems has forced us to evolve new strategies for a successful enterprise. It is no longer sufficient to be just a “profit making” firm but to become a knowledge generating and value maximizing organization to be called a truly successful enterprise. The success of FCI depends on the continued acquisition, deployment and funding of new knowledge. The focus of this paper is on the implementation of customerization¹ as a concrete paradigm and a scientific formalism for the manufacturing enterprise. A discussion of the key technologies, research challenges and the strategies for the implementation of such a system is given. The report thus envisions the important issues for the smooth and successful transition of FCI to a new manufacturing enterprise that will be the premier global manufacturing enterprise in the year 2030.

*FutureComp Inc. (FCI) is a fictitious company representing a manufacturing enterprise, the focus of this report is to provide a vision for the company in 2030.

Customerization in 2030: A Vision for the Premier Global Manufacturing Enterprise

1. INTRODUCTION

The CEO of FCI has stated the goal of positioning FCI to be a high-tech global manufacturing enterprise in the year 2030. In this report, I share my vision of how FCI can achieve this goal. The goal of this report is to develop a clear and concise vision of the future of engineering, postulate the needs of FCI in the world of 2030, and present solutions to these needs. This involves development and implementation of a customerization¹ strategy based on research and innovation which will promote the transformation of the enterprise, secure and create employment and create the maximum possible share of the manufacturing sector. Towards this end, steps towards formalizing product realization in a global marketplace are presented.

I begin my report with a brief overview of design and manufacturing in the year 2030. I present my vision of the world of 2030 around major drives such as technology, economy and communication and environmental considerations. Next, I present the position of FCI in the next 25 years with respect to the major drivers of success in the manufacturing sector. I present the partnerships that must be forged, the research challenges the FCI will face, and the core research directions to implement customerization as a scientific formalism of product realization in 2030. The key to the success of FCI is the continuous innovation it can implement in all aspects of the enterprise viz: manufacturing, sales, marketing and development. In the next section I present my recommendation of customerization as the future of product realization for the year 2030. Finally, a vision of the support technology and academic research needed to meet the needs of FCI in 2030 is presented. In conclusion, I present the limitations of this approach and avenues for future research.

2. REVIEW OF THE MANDATE

The following issues are to be addressed with regards to FCI as a competitive player in the global manufacturing scenario of 2030:

- The position of FCI in the year 2030.
- Research challenges and mode of operation.
- Partnerships that need to be forged.
- Goals that the company needs to achieve.
- Challenges that the company would face over the next 25 years.
- Technology that will be necessary and would have to be leveraged.

3. MANUFACTURING IN 2030

The world in 2030 will be characterized by the following trends that will have a profound impact on product realization in the manufacturing sector:

Globalization: An accelerated increase in the globalization of markets.

Higher Profitability: The financial markets will have a higher demand for profitability and demand greater productivity.

Customer Expectation: The customer expectations will be for greater personalization of goods and services.

Products: The customers will demand better and innovative products and being the “cheapest” will not be enough to ensure competitiveness in the global marketplace. Rapid advances in production technologies will facilitate rapid innovation of products and decrease production costs.

Manufacturing: Integration of manufacturing and design into a concurrent process as opposed to the traditional linear approach, leading to increase in complexity.

Environmental Issues: Tighter norms and policies to encourage manufacturing enterprises to adopt environmentally friendly manufacturing processes and materials.²

Competitive Climate: Knowledge sharing and greater communication will demand faster response to changes in the market trends.

Complexity: Most products will have a high degree of customization so that they could change and be re-configured during their lifecycles to meet changing needs of the customer. In order to be economically viable the products will have a modular, configurable structure and be based on product platforms.

4. THE COMPANY

For FCI to be successful it will have to possess an integrated set of attributes.³ The company will need to respond quickly to customer needs by rapidly producing customized, inexpensive, and high-quality products. This will require manufacturing facilities that can be quickly reconfigured to adapt to changing production needs and are operated by highly motivated and skilled knowledge workers. Workers organized in teams, both within and outside FCI will become a vital aspect of manufacturing. As participants in extended enterprises, next-generation FCI will only undertake that part of the manufacturing process that they can do better than others, something industry calls “adding value”. FCI will need to transform itself from a stand alone entity to an extended enterprise with multiple and ever-shifting business partners.³ Rapid introduction of complex, multifunctional new products to address emerging markets favors development of functional, modular components. It is clear that the traditional strategies of companies based on their core competence in manufacturing are being supplemented by new competitive strategies and competencies. These competencies are increasingly knowledge based and involve the application of advanced technologies developed in a scientific research environment. The future will be an era of “global knowledge economy” and will force a fundamental change in way manufacturing enterprises operate. The growth of FCI will depend heavily on the extent to which it can access and apply new knowledge and new ideas for innovative products and services. The manufacturing enterprises will give way to a “virtual enterprise”, highly collaborative in the digital domain on a global basis, multimedia, information-based, knowledge-integrated engineering tools, highly reliable communications system, distributed design and production, concurrent engineering, remote operation of manufacturing processes, product life cycle value, robust engineering, integrated design, manufacturing, and service, virtually defect-free products quickly, global customer service, see Rogers.⁴

The competitiveness of FCI will depend on its ability to secure the following differentiators of success in the global marketplace as shown in Figure 1 and described below:

Time: Quick customer satisfaction, shorter lead times, quick delivery of products.

Service: As the business is becoming service oriented there is a need for innovation, maintenance and after-sales service aimed at keeping the customer satisfied with the product.

Product Differentiation: Specialization, customerization as opposed to mass production, greater functionality of products.

Innovation: Continuous improvement of both the product and the process, highly automated production systems, commercialization of innovations.

Global Sourcing: Access technologies and skills from wherever the required criteria are met and not by geographic location.

Continuous Improvement: Implementation of lean manufacturing, Commitment to quality and zero tolerance for defects and customer-integrated design.

Agility: Flexibility in products, processes and operations.

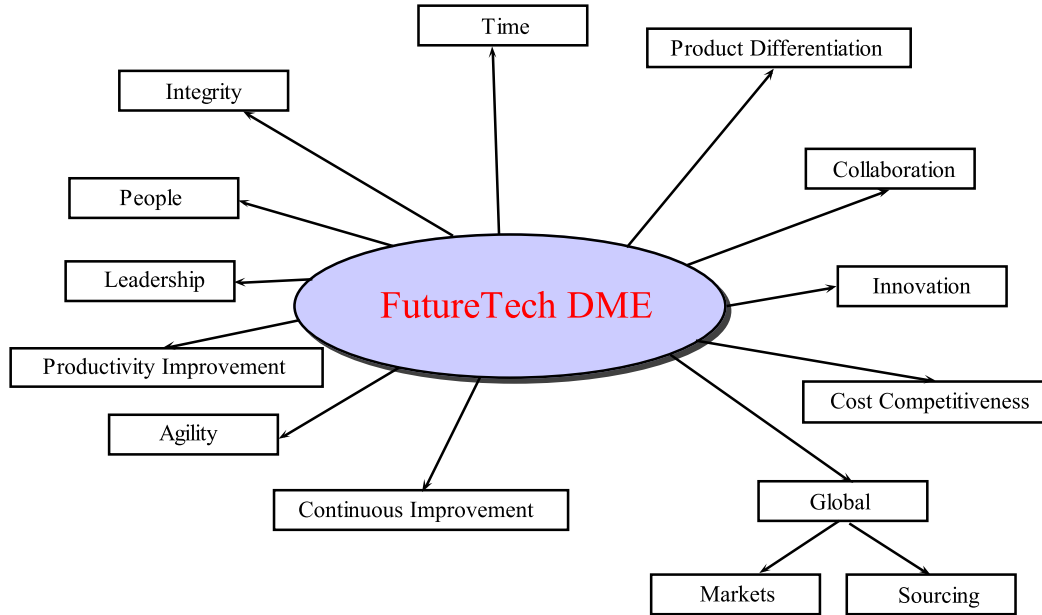


Figure 1. Differentiators of Success: FCI

Leadership: Proactive management, identification of potential business opportunities, motivating and creating a highly qualified workforce.

Collaboration: Strategic partnerships with companies and sharing of knowledge and resources, close relation with both the customers and suppliers.

Productivity Improvement: Driven by cost considerations and higher customer value.

Cost Competitiveness: Efficiency Improvement and elimination of waste, low cost automation.

5. GENERATION OF KNOWLEDGE

5.1 Direction of Research

In order to foster knowledge generation and ensure efficient transfer of the benefits to the enterprise, a new approach to innovation must be nurtured. An intimate collaboration between the academic communities and the enterprise would be of mutual benefit. Increased competition will demand a more effective research and innovation strategy. For the FCI to be sustainable in the future it should be able to innovate by investing in research and development in core areas of design and manufacturing. The knowledge gained from research in the core areas will foster innovations which will propel FCI to become a successful enterprise, see Figure 2. In this scenario the forging of partnerships with Research Centers and Universities becomes an integral part of the innovation process. The enterprise should encourage research in the areas of Product Data Management, Virtual Manufacturing, Simulation, Modular Manufacturing, Agile Manufacturing and Product Realization methodologies. FCI should also emphasize the implementation of technology innovations that translate into business value.

Information technology has opened up opportunities for enhanced application of information intensive activities that manufacturing industries are involved in - such as on-line monitoring and diagnostics of installed equipment and knowledge intensive processes such as new product development. The manufacturing companies are moving from a resource based to a knowledge based paradigm due to the permeation of digital technology in all the areas of the enterprise. In this era of digital manufacturing much attention should be paid to do path breaking research in digital product realization. Since the advent of the information technology age there are massive amounts of data related to the product that have to be processed, stored, retrieved and managed. Research and Development for the implementation of information technologies for product and process implementation

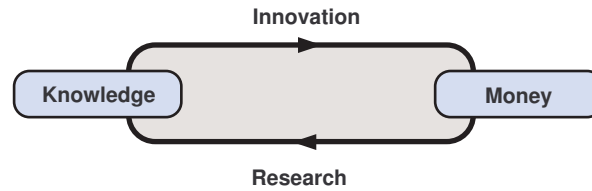


Figure 2. The Innovation-Research Loop

that are still at an infantile stage should be encouraged and funded. Investment in research will foster an increase in innovation potential. FCI should focus also on the exchange, management, and integration of information throughout the product and process life-cycle, as well as on the development of new design and engineering environments, see Mistree.⁵

5.2 Collaboration with Academia

Crucial to the company's future will be the ability not only to integrate research and innovation activities with education and training, but also to be effective in the formation of future managers and workforce. This requires collaboration between labs, suppliers, universities, competitors, manufacturers, funding agencies.⁶ There are inherent gaps in between the manufacturing industry and the research centers because of the lack of communication between the academia and the industry. A lot of the knowledge obtained from research is not exploited. This can be remedied by setting up liaisons in academia for keeping abreast of the latest developments in research. The collaboration between the industry and the research fraternity is an exercise in bridging two mentalities to facilitate commercial endeavors.

Initiatives for successful Research Partnerships with University/Academia:

- Research and Development contracts and cooperative research.
- Joint ventures for technology commercialization and technology transfer.
- Establishment of campus laboratories in research parks.
- Industry/University advisory boards and councils to identify key emerging areas for research.
- Higher Level Education for employees and summer Jobs for students and faculty.
- Patenting and technology licensing agreements.
- Employee exchanges and sabbaticals.
- Industry education and training partnerships.

In the information age, where success depends on the application of technology and knowledge management, the lines between business and academia are being blurred by partnerships that serve the dual purpose of delivering value to the company and advancing a university's academic and research missions. In this situation it would be a great benefit to have an academic liaison to manage the partnership. Both the communities will stand to get maximum mileage out of the relationship if the partnership is managed by the liaison. The primary functions of the liaison are shown in Figure 3.

5.3 Goals

For FCI to survive and flourish in the the world of 2030 the company must adapt itself to the market and technology. Mass production of identical products is no longer viable for many industry sectors. As market niches continue to narrow and customer preferences shift the mass production model is no longer economical to justify the costs. Customers still demand products with lower prices, higher quality, and faster delivery but more customized to match their unique needs.⁷ In order to meet these demands FCI must possess a



Figure 3. Functions of the Liaison

highly automated system dependent on technological skills and a knowledgeable workforce. The creation of an integrated knowledge community, embracing a whole gamut of manufacturing interests including customers, research partners and shareholders is essential to realizing the vision. Manufactured consumer products should be more efficient, durable and have more add on capabilities. The context in which FCI will work in the future will depend to a large extent on flexibility and speed as well as on localized production. Manufacturing will become increasingly service-intensive where the making a good product alone will not be sufficient to satisfy the customer. This will have consequences for the organization of production, supply-chain management and customer relations. Environmental challenges and sustainability requirements. FCI will have to comply with stricter environmental regulations as markets demand more environment-friendly materials and products. The company should adopt energy and resource-saving technology thus reducing wastage.

The manufacturing paradigm has seen a shift from the days of yore when it was resource based to the present day scenario where it is becoming increasingly knowledge based. Global integration has accelerated the worldwide flow of knowledge and information. This has invariably led to societies to becoming embedded in one another in complex ways, even as they retain their distinctive characteristics. Future Cyber infrastructure would allow for real-time collaboration and engineering system integration in engineering design. This will facilitate communication between the “Islands of Automation”. Issues related to interoperability, reusability of knowledge, information and resource sharing cost manufacturing industries billions of dollars each year. Facilitation of quick and accurate communication and information sharing among tools as well as between tools and human is the major challenge of today's engineering design tools. Cyber Infrastructure for engineering design should always target at shortening product realization time, improving quality, and reducing cost in product realization. Latest information technologies enable fast and better communication and information flow. However, generic infrastructure along will not solve current engineering design issues. Issues need to be solved include interoperable data and communication protocols, information and knowledge modeling standardization, security and trust management, resource repository and discovery, and cross-domain technology transfer, etc.⁸ Focus on emerging information and communication technologies are critical to product definition, conceptualization, design, development, and realization.

5.4 Challenges

At the product level, customer demands are more customized configurations, lower prices, higher quality, and faster delivery.²

The challenges to FCI in the year 2030 are:

- Reduction of product life cycle to meet the customers demands.
- Efficient supply chain management to handle the requirements of customerization and shorter product lifecycles.

- Transformation of information from a diverse array of sources to useful information for facilitating strategic decisions.
- Reduction of production waste and environmental impact of products.
- The right tradeoff between level of customization and manufacturing cost.
- Forming global strategic alliances towards becoming the “Reconfigurable Enterprise”.

The important areas that FCI will have to focus on as it moves towards becoming a global enterprise in 2030:

Supply Chain Management (SCM): Moving beyond traditional Enterprise Resource Planning (ERP) systems to the entire range of processes inside and outside of the company that add value to customers.

Virtual Enterprise: Develop partnership networks with both customers⁹ and suppliers and consequently become more responsive and cost effective thus adding value to the supply chain.

Modular product design: Using Product Data Management tools to aid the development of highly customizable products simultaneously keeping the costs low.

Agile manufacturing: improving the capability of the plant adapt to changes in design and strategy.

The Web: capitalizing on the Internet to gain quick access and use of information throughout the virtual enterprise thus reducing communication lag.

Modular Design: Modularize components to be able to customize products and services.¹⁰ One criteria for modular design is to enable the creation of the custom configuration as late in the order fulfillment cycle as possible

6. VISION 2030

In FCI’s drive for becoming a successful manufacturing enterprise in 2030, accelerating time-to-market, robust IT capabilities become paramount. Design and manufacturing, web-based collaboration swift, accurate, seamless, and easy to use becomes imperative. To facilitate the linking of the many product design and development software tools both within the company and its supply chain the IT environment must accommodate a wide mixture of systems in a heterogeneous environment. There must be a high degree of flexibility to cope with frequent and unexpected changes in the company’s environment. Fortunately, new technologies are emerging to facilitate the exchange of data across the boundaries of the supply chain.

6.1 Customerization: The Next Wave

The vision for the FCI embraces the complex network linking human and societal needs (demand) to both the industrial and education systems (supply).¹¹ It is intended as a framework to guide the development of foresight into the strategic future of manufacturing possibly leading to the formulation of a manufacturing platform for FCI as the basis for concerted action to achieve success.

According to the Next Generation Manufacturing³ report, key drivers or forces that shape the future competitive environment of the twenty-first century are:

- Ubiquitous availability and distribution of information.
- Rapid change in technology.
- Rapidly expanding technology access.
- Globalization of markets and business competition.
- Environment responsibility and resource limitations.

- Increasing customer expectations.

Manufacturers will face greater demands like shorter product life-cycles and increasing competition. This is will warrant a shift from traditional process-centered work practices in favor of radical new manufacturing paradigms like modular manufacturing and digital manufacturing resulting in improvement in product and process features shown in Figure 4.

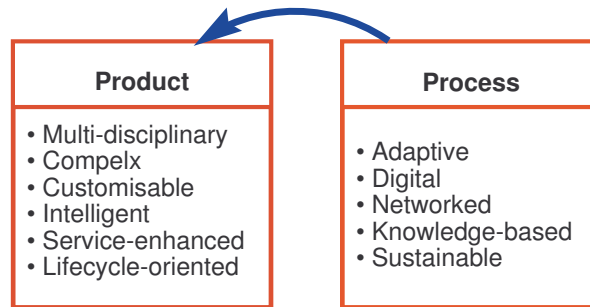


Figure 4. Features of Future Products and Processes

Product Realization is the process by which an organization:¹²

1. Identifies customer needs and product performance,
2. Plan the design and manufacturing processes to include the product life cycle, distribution, support, maintenance, recycling, and disposal
3. and plan for product improvement.

Thus the term “product realization” encompasses design and manufacturing processes and includes enterprise planning, supply chain management, global communication and e-business.

The explosion in knowledge sharing, coupled with advances in technology, will provide the ability to achieve a new era in customerization¹, a buyer-centric business strategy that combines mass customization with customized marketing. Many enterprises are transforming the practice of marketing from being seller-centric to being buyer-centric. They call this emerging paradigm “customerization” and describe it as “a call to the marketing profession to rise to a new standard of interacting with customers and building relationships with them”.¹ This consequently leads to greater interaction between the consumers and the manufacturers to create better value for consumers. As opposed to the traditional methodologies, there is a continuous interaction with the customer as opposed to a few marketing surveys. Thus there shift from one-way communication during the product realization process to two-way communication. Manufacturing enterprises will now elicit preferences on the product and the service from the consumer and incorporate these into the product so that the manufactured product aligns exactly with the needs of the consumer. Mass customization and Customerization are both buyer centric manufacturing paradigms however Mass Customization is IT-intensive on the production side whereas customerization is IT-intensive on the marketing side as shown in Figure 5. Coupled with standardization and modular design is the use of Product Configurator software,¹³ software modules with logic capabilities to create, maintain, and use electronic product models that allow complete definition of all possible product options. The current logic based product configurator models however are rule and logic based and fall short of the expectations for customerization. The configurator models should be more flexible with integration of Product Data Management systems to allow for seamless integration of the various processes.

Customerization demands the social interaction of engineers with customers and consequently increase the demand for engineers with well developed social and personal skills. New tools in manufacturing and production, new knowledge about the products being produced and the customers that use them, and the ease with which information and products can be transferred will enable the creation of products and services that are uniquely

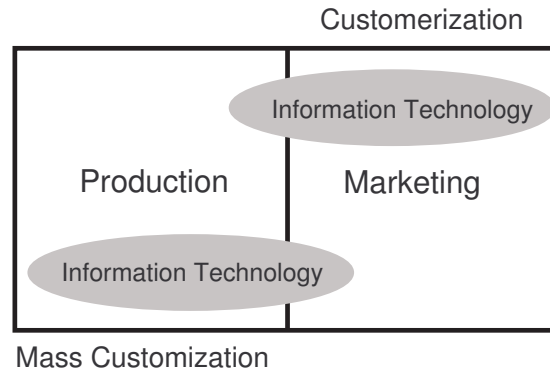


Figure 5. Mass Customization and Customerization

designed for the user. Manufacturers will have the ability to embed adaptive features into automated processes, including the capacity to respond to real-time information provided by the user and/or other entities. Consumers will demand products that are tailored to their needs and intended uses based on the most unique attributes. The concept of made-to-order products will continue to expand as made-to-order ability may become a necessity for survival in the near future. Engineers will be asked to accelerate and expand customerization as businesses compete to build and maintain a strong customer base irrespective of the geographic location of the customers. In developing customerization strategies, however, companies face a number of challenges. These include obtaining information from customers, identifying intangible factors that may be crucial to customers, dealing with enhanced customer expectations, limiting the complexity of options, and pricing customized offerings.

Quick response to customer demands and a high level of innovation are two observed features of successful engineering and manufacturing companies, see Harris.¹⁴ Engineering thus becomes an integrated part of the product realization process where the customer's demands are met in the form of products, manufacturing systems, or processes. Also of pivotal importance is keeping customers informed of emerging opportunities brought on by new capabilities improving the customers ability to achieve their goals.

Customerization tends to smaller batches and would lead to a reliance on flow manufacturing. Whether manufacturing a wide variety of standard products or customized products, FCI would have to depend on flow manufacturing to build products economically in any order quantity, even as low as one. Being able to build in small batch sizes depends on the elimination of setup, for instance, to get parts, change dies and fixtures, download programs, find instructions, or any kind of manual measurement, adjustment, or positioning of parts or fixtures. If setup can be eliminated, then products could be made-to-order as orders came in. This is the essence of spontaneous Build-to-Order. Setup elimination is also an essential prerequisite for customerization since every product should be different and still be economically viable for the enterprise.¹⁵ Customerization is a combination of both customized operations and customized marketing¹ as shown in Figure 6. It is different from one to one marketing which delivers standard products and services to customers through customized marketing, and mass customization which delivers customized products and services through standardized marketing.

Successful implementation of customerization involves abandoning the tightly integrated networks that form the backbone of the continuous improvement organization in favor of a loosely linked collection of autonomous modules. Each module performs a different task and is continually reconfigured in response to customer demands. Automation typically is the key to linking these modules so that they can come together quickly and efficiently the organization will have to be very agile because of the ever changing demands of the customer. Thus the enterprise will be forever changing and expanding its range of capabilities and knowledge. FCI should focus on combining key IT elements into a seamless infrastructure focused on the benefits of customerization.

6.2 Challenges in Customerization

Implementing customerization creates major systems needs that FCI must address. It is a design paradigm that is virtual service oriented. Defining the right degree of customerization options is a major success factor

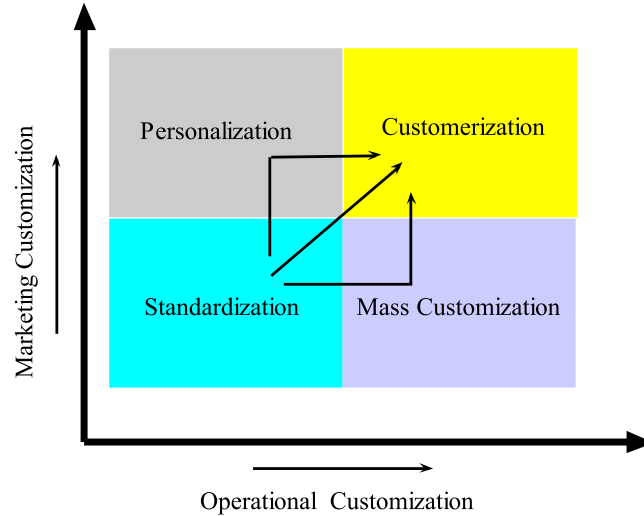


Figure 6. Pathways to Customerization (Wind and Rangaswamy)¹

of any customerization strategy. Customerization translates into practically an infinite variety of products thus increasing the complexity of product platform exponentially. Until now much attention has been given to the impact of customization on manufacturing, however research into the impact of customization on other functions like marketing or design is just beginning.¹ Knowledge about procedures and problems of consumers configuring goods and services on the internet¹⁶ is still very limited. This should be the focus for future research.

There is also still a lot of research needed in order to transfer the tools and principles from the area of knowledge management to a company that is no longer based on the manufacturing of products but on interacting with each single customer.¹⁷ Further attention has to be paid to establish tools and instruments to transfer the knowledge gained during the integration process into new competencies. For customerization to be successful information is the driving force and therefore new information technologies are the major drivers for customerization.

The challenges that FCI will face whilst implementing customerization are even greater than mass customization due to the greater variety of the products manufactured. There have been concerns about the success of mass customization which may well extend to customerization. While customerization is a promising and beneficial approach to meet today's market demands there are limitations to this concept. One limit of mass customization often quoted is that excess variety may result a lot of complexity discussed in Teresko,¹⁸ this is certainly much more relevant in customerization. Customers can be overwhelmed by the number of choices during product configuration as detailed by Friesen¹⁹ and Kahn.²⁰

FCI should thus prioritize improvement and implementation of the following,

- Establishing standards for modelling each task in the product cycle and structuring the customerization process.
- Reducing the customer labor in the process.
- Improvement of the user interfaces for the customer.

7. CONCLUSION

The goal of this report is to develop a vision for the future of FCI as a premier global manufacturing enterprise. In order to achieve this FCI should endeavor to form close relationships with the research community and the customers. These relationships when nurtured will propel FCI to the apex of the industrial world of 2030

as a leading manufacturer and innovator. FCI must differentiate itself by the quality of service and support to customers, in addition to product quality. FCI should continuously improve the the product design and development process to realize an “agile” facility and organization. FCI can achieve success by embracing supporting technologies for customerization. Implementation of the measures postulated in this report will enable FCI to expand its knowledge base through world-class research, and to exploit its discoveries to maximum advantage in the development of novel products and product-related services.

It is my enduring belief that if the company forges the mentioned relationships and invests time and money into cutting edge research in the critical areas and commits itself to becoming a knowledge based organization it will be successful over the next quarter of the century. In a world that increasingly demands instant satisfaction from personalized and customized products at low cost, customerization is the way for the future. I am excited at the prospect of working with FCI towards this goal and spurring FCI to the forefront of global manufacturing in 2030.

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