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MASS CUSTOMIZATIONS APPROACH USING DESIGN STRUCTURE MATRIX

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1 INTRODUCTION

Today's intense competitive market place, mass production of identical products is not sufficient to survive rather producing products for specific customer need is essential. The only way to gain in business is to adopt a customer driven strategy which delivers products and services to meet customer expectations [1]. The role of customer demand information is therefore extremely critical to the success or failure of new product introduction [2]. Yet, customer requirements are seldom gathered and it is even rarer that this valuable information is shared between marketing and R&D or made available to design engineers [3]. The prime goal of any production enterprise is to make profits and this can be achieved to producing the right products and services in right time which in turn reduce cost and reduce design and implementation times.

Product design and development is directly connected with customization. Product customization has recently attracted interest due to the growing demand of 'mass customization'. In industrial organization, however customization is not new and has always been predominant. Customized product means custom-build products or custom-designed products produced to customer satisfaction.

This paper presents an approach of mass customization using DSM [4]. The following section presented a framework for mass customization approach using DSM. Next, the paper shows an example and explains how DSM can be implemented to represent different design rules of Volvo Company trucks for customization. A relationship framework among customer requirements, organizational implications and design elements was also presented. Finally, the conclusion summarizes the key points, discussing how DSM can be implemented successfully for mass customization.

2 INTEGRATION OF DSM TOOL FOR MASS CUSTOMIZATION

The design and development of customized product is very important phase in an organization. In order to response quickly to the customer needs, product development process needs to be integrated with automated interactive framework which enhances product development activities. The concept of integrated framework is shown in Fig 1.

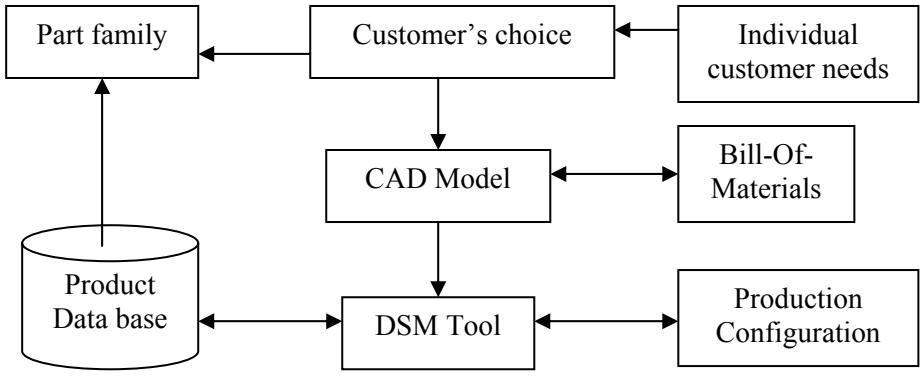

Figure 1. Integrated framework for customized product

From Fig.1 we can observe that individual customer needs mobilize customer's choice process which has a direct relation with CAD model and part family. Part family that needs required information for different parts specifications is connected to product data base (PDB) which is also inter-woven with DSM tool. CAD model gets the required information about a custom-designed product from

customer's choice and communicate with Bill-of-materials (BOM) to produce that. Production configuration efficiently allocates different resources for manufacturing the product after getting the sequenced tasks from the DSM tool.

3 THE APPLICATION OF DSM IN MANAGING DESIGN RULES: AN EXAMPLE

The DSM in Fig. 3 delicately representing the various design rules of Volvo Company for manufacturing different models of truck [5]. The design rules are shown in Table 1. From Fig. 3 we can easily find out the different restrictions of choosing a model according to customers need. This figure demonstrates how DSM can be used as an organized tool for representing the design rules contains in Volvo Company. The red boxes within the DSM represent the denial of a particular feature of an engine model, whereas blue boxes are the set value by default and green boxes indicates the acceptance of the rules.

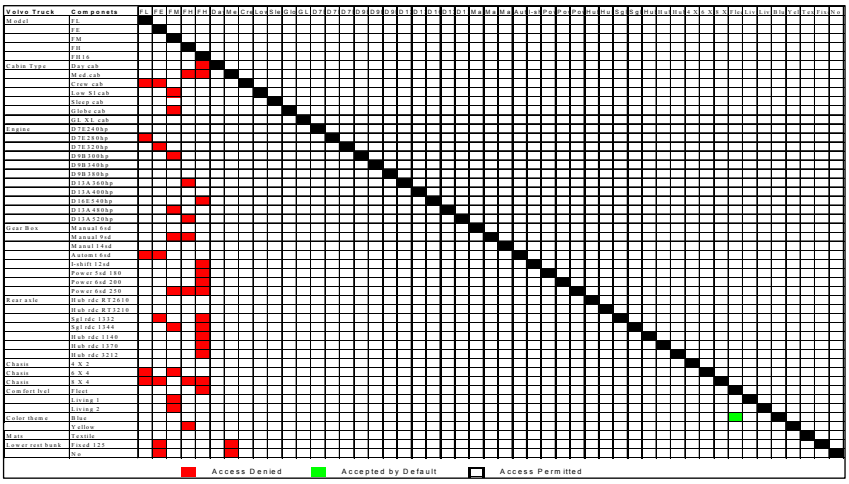

Figure 2. Application of DSM for representing the design rules of Volvo company trucks

Table 1. Design rules of Volvo Company for manufacturing trucks

1.	IF Model < FM - FM ==> DENY Cabin type >= Globetrotter Cab - Globetrotter Cab AND DENY Upper rest bunk = Narrow – 1
2.	IF Model != FL - FL ==> DENY Cabin type = Crew Cab - Crew Cab
3.	IF Model > FE - FE ==> DENY Cabin type = Crew Cab - Crew Cab
4.	IF Model = FL - FL ==> DENY Chassis = 6X4 - 6X4 AND DENY Chassis = 8X4 - 8X4
5.	IF Model = FE - FE ==> DENY Chassis = 8X4 - 8X4 AND SO ON…….

4 RELATIONSHIP AMONG CUSTOMER NEEDS, DESIGN ELEMENTS AND ORGANIZATIONAL IMPLICATIONS

The interrelationship among customer needs, design elements and organizational planning is very much related with product development. Before launching a product it is essential to identify and prioritize customers' taste and planning managerial implications and product design accordingly to satisfy those customers. There is often a poor connection among customers, management personnel and designers especially in multi-disciplinary design. This is because the lack of a focus or mechanism of directly addressing customer satisfaction and limitation in collaborative working. Figure 3 shows an example of a dependency mapping among different customer needs, design tasks and organizational units. In Figure 3, (i) represents the domain mapping matrix [6] of customer needs with ranking of a scale of 1 to 10 as highest value, (ii) represents the DSM of design components of Volvo trucks and (iii) for the DSM of inter unit or departments relationship of the organization.

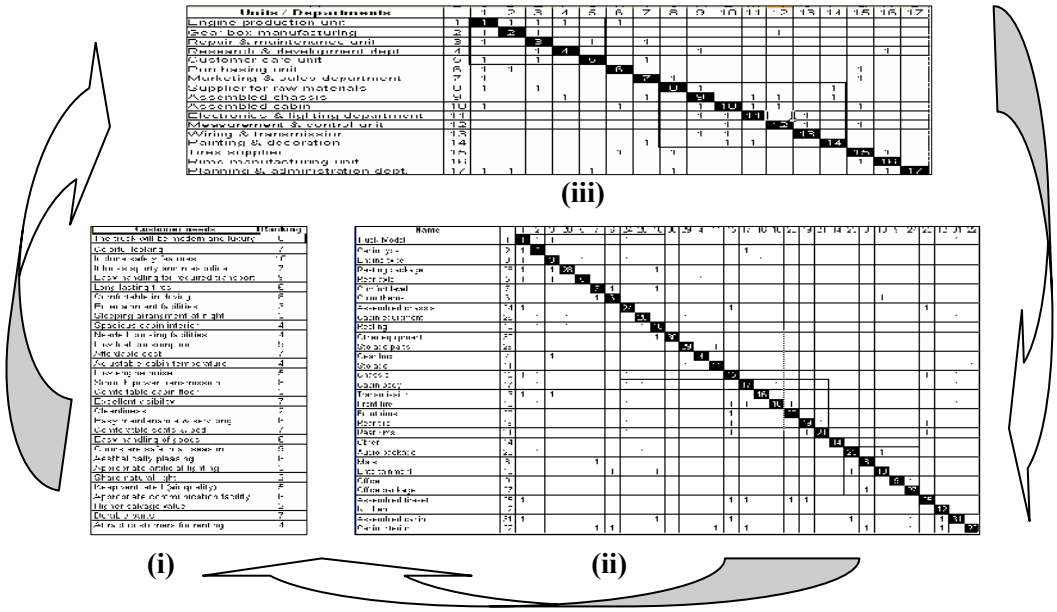

Figure 3. Mapping among (i) customer needs (ii) design elements and (iii) organizational dependencies.

5 CONCLUSIONS AND FUTURE RESEARCH

Mass customization is a reality in today's manufacturing environments. The approach to mass customization where the customer participates directly/indirectly in the design and product definition stage, taking advantage of design-to-order. In this paper we have demonstrated briefly different customization features such as; product modularization, parts commonality, product platform etc. along with an integrated framework for manufacturing customized products using DSM as an advanced tool for task sequencing. This paper also outlines the application of different design rules of Volvo company truck using DSM which help customers to guide their choices and shows an integrated customer oriented framework for truck manufacturing. Future research could be carried out to upgrade the integrated DSM framework by adding more design modules such as supply chain management systems, production planning strategy etc. to make it more flexible. Another extension has to be done to accommodate all design rules in a single DSM which at present seems very difficult to do. In that case programming software may be developed to overcome this problem.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Wallac T.F. 1992. *Customer-Driven Strategy, Winning Through Operational Excellence,* 1992 (Vermont, Oliver Wight Publications).

[2] Ottum B.D. and Moore W.L. The role of market information in new product success/failure. *Journal of Product Innovation Management*, 1997, 14, 258-73.

[3] Omar A.R., Harding J.A. and Popplewell K. Design for customer satisfaction: an information modeling approach. *Integrated Manufacturing Systems*, 1999, 10(4), 199-209.

[4] Steward D.V. The Design Structure System: A Method for Managing the Design of Complex Systems. *IEEE Transactions on Engineering Management*, 1981, 28(3), 71-74.

[5] Kyllönen S. and Helo P. Web-based reconfiguration platform for online collaborative product customization. *CATER Project, No. IST-5-034030-STREP, WP.3*, April. 2007.

[6] Danilovic M. and Browning T.R. Managing complex product development projects with design structure matrices and domain mapping matrices. *International Journal of Project Management*, 2007, 25(3), 300-314.

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9TH INTERNATIONAL DSM CONFERENCE

Mass Customizations Approach Using Design Structure Matrix

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Presentation Outline

- Introduction
- Benefits of mass customization
- Mass customization features
- Integration of DSM tool for mass customization
- The application of DSM in managing design rules: An example
- Relationship among customer needs, design elements and organizational implications
- Managerial implications
- Conclusion and future research

Introduction

- Customized product design and development is directly connected with customers choice which has recently attracted interest due to the growing demand of 'mass customization'
- To survive in today's competitive world mass production is not sufficient but mass customization is essential for a company's success
- Adoption of mass customization principle helps companies to reduce the costly inventory and gain market segment
- Customized product means custom-build products or custom-designed products produced for customer satisfactions
- The prime goal of any production enterprise is to make profits and this can be achieved through producing the right products or services in right time which in turn reduce cost and reduce design and implementation times
- It is essential to deliver products in a way which requires design engineers to focus on customers need and how design parameters satisfy customer demands

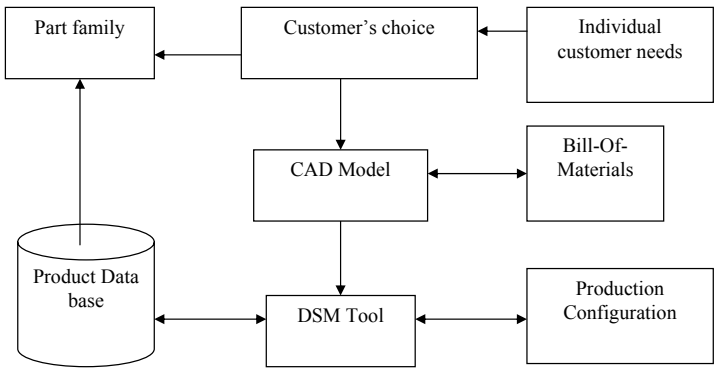
Benefits of mass customization approach

- Higher customer satisfaction
- Steady increase of revenue
- Stability in business process
- Reduce cost of inventory
- Proper use of the resources
- Enhance customer designer relationship
- Increasing team coordination
- Uplift management moral
- Product individualization or variety brings enterprises to offer more choices to the customers
- This concept helps companies to deliver customized products with reduce costing and high quality

Mass-customization features

- To fulfill individual customer need, manufacturing companies have to adopt several strategies in their business goal such as; common product platform or proliferation, product configuration, production configuration, part commonality, modularization in design etc.
- Product platform denotes the collection of elements shared by several related products are the base of making product varieties and the associated product family
- Product configuration is a tool that helps customers to choose individual needs
- Production configuration is also a tool to manipulate manufacturing system according to customers requirements
- Part commonality reflects the extent of similar products elements to shorten the product design and production process
- Modularization or parts standardization enhances product varieties through creating commonality of components parts which can be reused for different products

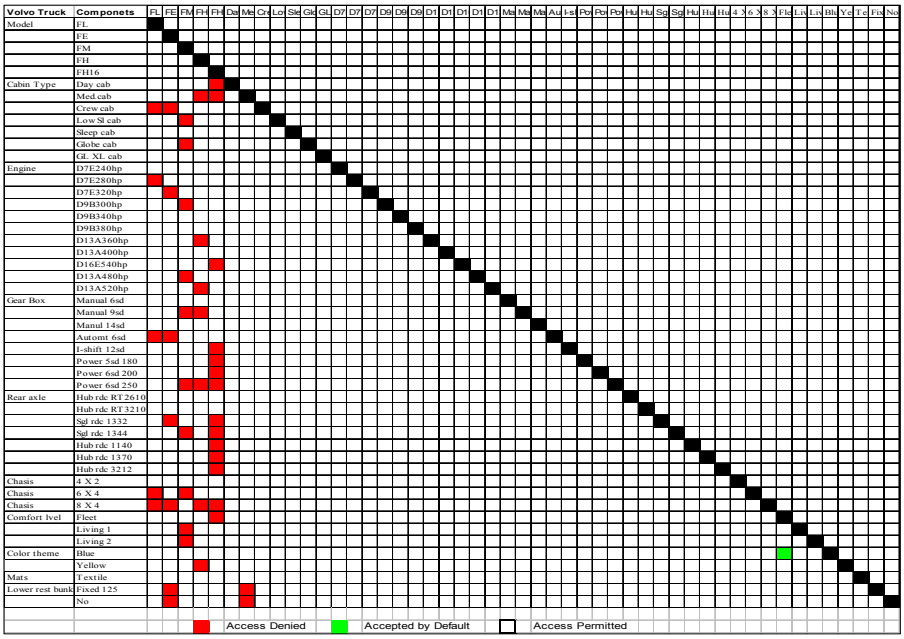
Integration of DSM tool for Mass Customization



Integration of DSM tool for Mass Customization

- The proposed framework maintains a linkage among customer requirements, product design and production processes
- This automated interactive framework helps to manufacture product more quickly, economically and efficiently
- It is an approach to enhance quicker respone to the customer needs
- Facilitates direct customer participation in design and production process
- Mobilize market information to the production site
- Maintain proper tracking of Bill-Of-Materials (BOM)
- The DSM tool is used to optimize the tasks ordering which also helps to minimize the iteration or feed back loop as minimal as possible

The application of DSM in managing design rules: An example



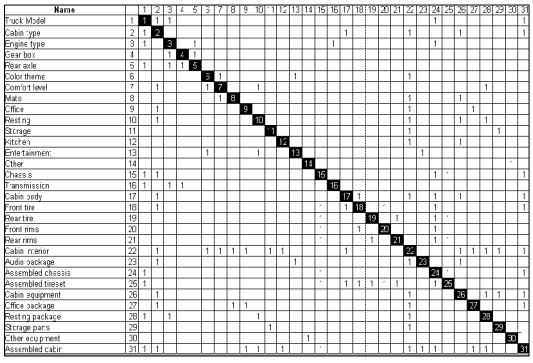
Volvo Design Rules

1.	IF Model < FM - FM ==> DENY Cabin type >= Globetrotter Cab - Globetrotter Cab AND DENY Upper rest bunk = Narrow – 1
2.	IF Model != FL - FL ==> DENY Cabin type = Crew Cab - Crew Cab
3.	IF Model > FE - FE ==> DENY Cabin type = Crew Cab - Crew Cab
4.	IF Model = FL - FL ==> DENY Chassis = 6X4 - 6X4 AND DENY Chassis = 8X4 - 8X4
5.	IF Model = FE - FE ==> DENY Chassis = 8X4 - 8X4
6.	IF Model = FM - FM ==> DENY Chassis = 6X4 - 6X4
7.	IF Model = FH - FH ==> DENY Chassis = 8X4 - 8X4
8.	IF Model = FH16 - FH16 ==> DENY Chassis = 8X4 - 8X4
9.	IF Model != FM - FM ==> DENY Side document box = Yes - 1 AND DENY Front document box = Yes - 1
10.	IF Model <= FE - FE ==> DENY Air Conditioning = Automatic - Automatic
11.	IF Model <= FE - FE ==> SET DEFAULT Air Conditioning None - 0
12.	IF Model != FM - FM ==> DENY Comfort level = Living 1 - Living 1 AND DENY Comfort level = Living 2 - Living 2
13.	IF Model = FH16 - FH16 ==> DENY Comfort level = Fleet - Fleet AND DENY Cabin type = Day Cab - Day Cab AND DENY Cabin type = Medium Cab - Medium Cab
14.	IF Model != FM - FM ==> DENY Cabin type = Low sleeper Cab - Low sleeper Cab
15.	IF Model = FH - FH ==> DENY Cabin type = Medium Cab - Medium Cab
16.	IF Comfort level = Fleet - Fleet ==> SET DEFAULT Interior colors Blue - Blue
17.	IF Model < FH - FH ==> DENY Mats = Textile - Textile
18.	IF Comfort level = Fleet - Fleet ==> DENY Instrument panels = Wood - Wood AND DENY Instrument panels = Metal – Metal
19.	IF Model = FE - FE AND Cabin type = Medium Cab - Medium Cab ==> DENY Lower rest bunk = Fixed 125 - Fixed 125 AND DENY Lower rest bunk = No – 0
20.	IF Model = FL - FL ==> DENY Engine > D7E 280hp - D7E280 AND DENY Gear box > Automatic 6-Speed - Automatic 6 AND DENY Rear axle > Hub reduction 1140 - RSH1140
21.	IF Model = FE - FE ==> DENY Engine > D7E 320hp - D7E320 AND DENY Gear box > Automatic 6-Speed - Automatic 6 AND DENY Rear axle < Single reduction 1332 - RSS1332 AND DENY Rear axle > Hub reduction 2180 - RTH2180
22.	IF Model = FM - FM ==> DENY Engine < D9B 300hp - D9B300 AND DENY Engine > D13A 480hp - D13A480 AND DENY Gear box < Manual 9-Speed - Manual 9 AND DENY Gear box > Powertronic 6-Speed 250 - Powertronic 2506 AND DENY Rear axle < Single reduction 1344 - RSS1344 AND DENY Rear axle > Hub reduction 3212 - RTH3212
23.	IF Model = FH - FH ==> DENY Engine < D13A 360hp - D13A360 AND DENY Engine > D13A 520hp - D13A520 AND DENY Gear box < Manual 9-Speed - Manual 9 AND DENY Gear box > Powertronic 6-Speed 250 - Powertronic 2506 AND DENY Rear axle < Hub reduction 1370 - RSH1370 AND DENY Rear axle > Hub reduction 3212 - RTH3212
24.	IF Model = FH16 - FH16 ==> DENY Engine < D16E 540hp - D16E540 AND DENY Gear box < I-Shift 12-Speed - I-Shift 12 AND DENY Gear box = Powertronic 5-Speed 180 - Powertronic 1805 AND DENY Gear box = Powertronic 6-Speed 200 - Powertronic 2006 AND DENY Gear box = Powertronic 6-Speed 250 - Powertronic 2506 AND DENY Rear axle = Single reduction 1125 - RSS1125 AND DENY Rear axle = Single reduction 1132 - RSS1132 AND DENY Rear axle = Hub reduction 1140 - RSH1140 AND DENY Rear axle = Single reduction 1332 - RSS1332 AND DENY Rear axle = Single reduction 1344 - RSS1344 AND DENY Rear axle = Hub reduction 1370 - RSH1370 AND DENY Rear axle = Hub reduction 2180 - RTH2180 AND DENY Rear axle = Hub reduction 2110 - RTH2110 AND DENY Rear axle = Hub reduction 2610 - RTH2610 AND DENY Rear axle = Hub reduction 3210 - RTH3210 AND DENY Rear axle = Hub reduction 3212 - RTH3212

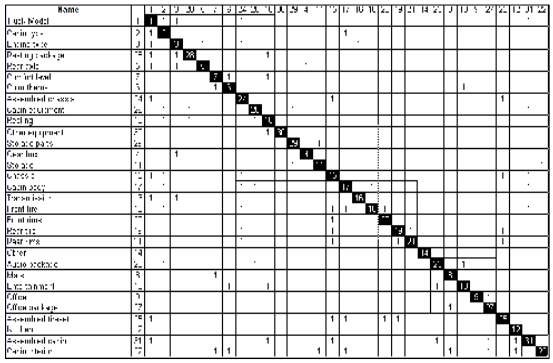
Volvo Design Rules: An Example

- DSM can be used as an organized tool for representing the design rules of any company
- Integration of DSM with design rules guides customers to choose the best among different alternatives
- Customers are directed of their choices with some restrictions
- The red boxes within the DSM represent the denial of a particular feature of an engine model, whereas blue boxes are the set value by default and green boxes indicate the acceptance of the rules
- In this simplistic way DSM can be used to represent the design rules in a brief matrix format rather than maintaining pages of documents
- This brief representation of design rules help manufacturers to customize their products in a nice and easy fashion

DSM mapping among different design elements and their relationships



before sequencing and clustering



after sequencing and clustering

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DSM mapping among different design elements and their relationships

- Reduce task dependencies after partitioning
- Minimum number of iterations
- Reduce product lead time
- Develop manageable clusters
- Facilitate more concentration among clusters
- Enhance quality in product design and development
- Helps to focus on critical tasks

Relationship among customer needs, design elements and organizational implications

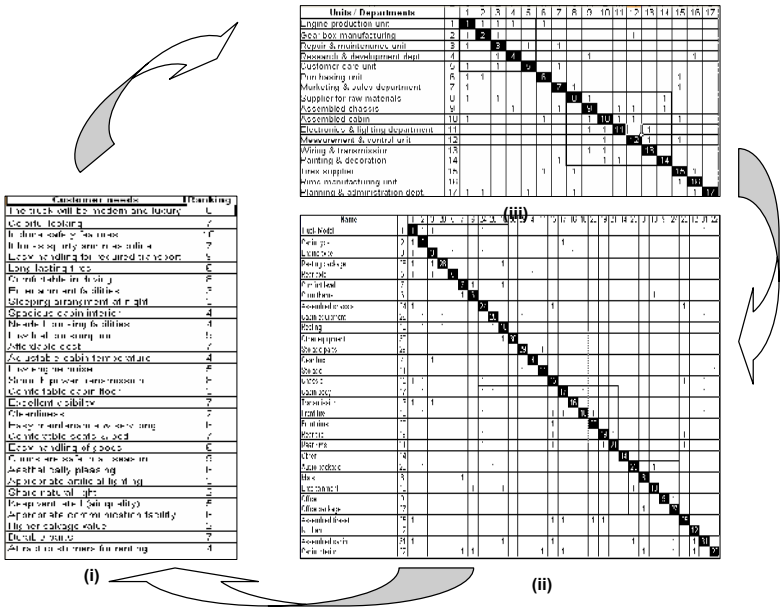

Figure: Mapping among (i) customer needs (ii), design elements and (iii) organizational dependencies

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Relationship among customer needs, design elements and organizational implications

- This relationship mapping illustrates how to coordinate among different customer needs, design components and logistics departments
- It is focused on inter-dependencies and the need for information exchange between customers, organizational units and design teams
- This cyclic information exchange facilitates project managers to get an insight view before implementing any PD projects
- Before launching a product it is essential to identify and prioritize customers' taste and planning product design accordingly to satisfy those customers
- From this relationship mapping, designers can optimize their product development process after closely monitoring with internal and external design criterion
- This offers administration a reasonable ground to prioritize their works for efficient problem solving through special attention on constrains

Managerial implications

- This work pointed out the dynamics of mass customization and presented a framework for analyzing different design elements that guide managers to give special attention on customized product development activities
- It is focused basically with the integration of sophisticated method DSM for producing customized products through ascertaining the visibility of design dependencies that enables more efficient problem solving
- DSM provides a more quantitative and analytical approach for mass customization and product design strategies
- In business, product customization can be aided by giving attention to product modularization, part commonality, product family architecture etc. and on three aspects such as; time to market, variety and mass efficiency to keep the manufacturing cost low
- The integration between design and manufacturing produces a better and simpler product which is easier and cheaper to manufacture and in the meantime maximizes customer value with gaining competitive advantages

Conclusions and future research

- Mass customization is a reality in today's manufacturing environments. It is a manufacturing and supply chain management strategy that allows a product manufacturer to deliver efficiently with many variations of a standard product
- This mass customization approach where the customer participates directly/indirectly in the design and product definition stage, taking advantage of design-to-order and it also guides a designer in a more negotiable way to develop a product
- In the product development scenarios, there will always be inter-woven between product components and features. For customized products different features need to be readily available from which customers can choose easily with spending minimum time
- In this research, particular attention was given to facilitate customized product development scenarios which are facing the challenges of keeping mass producibility and profitability with higher quality
- Future research could be carried out to upgrade the integrated DSM framework by adding more design modules such as supply chain management systems, production planning strategy etc. to make it more flexible
- Another extension can be done to accommodate all design rules in a single DSM which at present seems very difficult to do. In that occasion a programming software could be used to overcome this problem