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CROSS-FUNCTIONAL PRODUCT DEVELOPMENT TEAMS FOR ENHANCING THE EFFECTIVENESS OF SUPPLY CHAINS IN THE HOUSING INDUSTRY

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ABSTRACT
The housing industry provides enough challenges for mass customization. Our work is aimed at characterizing some supply chains that continually add value to the customers in the Housing Industry. The existence of inter-departmental barriers and the lack of inter-organizational collaboration affect customer satisfaction in this Industry. The focus, therefore, will be on the use of cross-functional teams.

We will be presenting concepts that link quality function deployment (QFD) with supply chain management (SCM). The QFD process provides a cross-functional approach that uses a planning tool called the House of Quality (HOQ) for organizing and linking the customer survey information with the product design attributes and later deploying it in stages throughout the organization. Customer feedback is used by the cross-functional team to make engineering, marketing and design decisions. These tools can be extended to support inter-organizational interactions thereby enhancing the effectiveness of collaborative product development ventures. Supply chains wanting early design involvement of key chain members can use these support systems that can deploy the voice of the customer with minimum distortion along the value chain. Effective implementation of these tools through cross-functional teams will improve concurrency and enhance mass customization capabilities.

KEYWORDS
Concurrent Engineering, Virtual Collocation, Mass Customization, Feedback Mechanism, Quality Function Deployment

1. INTRODUCTION

The housing industry has a major contribution towards the infrastructure development. The industry not only caters the demand of mass housing but also of modern day needs of sophisticated market complexes, multistoried buildings with all the facilities and specialized official complexes. These projects are expected not only to be completed within allocated time and budget but also should be functionally satisfactory to the customer. In the present study, we look at the housing industry from a supply chain perspective – i.e. from the supplier's supplier to the customer's customer.

With globalization fast becoming a reality, global supply chains extending into potential markets in South Asia need to develop better alliances with key members. Better systems are needed for supporting inter-organizational collaborations between various members of the supply chain. It is as much important for the focal organization to develop ties with upstream members, as it is to maintain relationships with the downstream members. Under the liberalized business environment, Indian organizations need to adapt quickly to systems having better value-chain orientation. The existing domestic and international chains in India comprise of organizations having characteristics that are best suited for a slow economy with monopolistic market conditions. While world-class organizations find it easier to get oriented along the value chain, Indian organizations find it difficult to shed their old organizational work culture. In many organizations the structures are still hierarchically oriented with little cross-functional interaction. As a result there is resistance to breaking of barriers between departments. While supply chain concepts are aimed at breaking barriers between organizations, Indian organizations have still not overcome the internal departmental barriers. They have yet to reach the levels of efficiency exhibited by organizations having high degree of customer orientation.

From various implementation efforts of other organizations we have noted how difficult it has been to sell the ideas of just in time (JIT) manufacturing to either JIT purchasing or JIT distribution. Though attempts are on to create quality awareness, the housing Industry is also slow in adopting these concepts. It is partly because of the resistance posed by individuals and groups within organizations. Even though some organizations have achieved higher levels of efficiency, other supply chain partners have inhibited them from satisfying their end customers. The customer expectations are not met because of the difficulty faced in deploying the voice of the customer along the entire chain. In many cases these chains pass through several organizations. Many of these organizations have an adversarial relationship. To move to a collaborative relationship is not possible without the appropriate technological support.

In this paper we discuss a framework for deploying the voice of the customer throughout the chain with the help of better software capabilities. We resort to automated development of house of quality (HOQ) matrices with better front-end capabilities aimed at effectively engaging cross-functional teams (CFTs). In their survey of literature, Mabert and Venkataramanan (1998) have identified some of the future research directions with a special focus on supply chain linkages. One of the research directions is aimed at studying the impact of the product development function on the supply chain configuration. Similarly, Cohen and Mallik (1997) have identified several issues that need attention. One of the areas of interest to us is that of inter-firm coordination. In this paper we present our proposed line of research, which links product development with supply chain collaborations in the housing industry. In the following sections we first present a conceptual framework that extends the House of Quality matrix for encompassing supply chain entities. This framework provides support to the various organizations in deploying the voice of the customer along the value chain. This proposed framework is then to be applied in our research, which has two broad design dimensions. The first dimension deals with designing robust products for supply chains in the housing industry. The second dimension, which is beyond the scope of this paper, deals with designing robust supply chains. A robust supply chain is one that is able to adapt itself to real time dynamic data under disastrous environmental stimulus.

2. QUALITY FUNCTION DEPLOYMENT AND CROSS FUNCTIONAL TEAMS

In a competitive business environment it is important for companies to understand and satisfy the needs of their customers while being sensitized to the limitations of their partners. Since customer preferences are varied it becomes very difficult to aggregate their needs within a single standardized product that can be mass-produced. Hence we face the challenges of mass customization where it becomes important to listen to the voice of the customer and deploy it through the organization with minimum distortion. Understanding the stated and implied needs of the customer is, therefore, vital for any organization wanting to succeed by developing new products. They need to translate the user-based definitions of quality into producible product-based definitions. One method of translating the voice of the customer into design specifications of a product is **quality function deployment (QFD)**. In this section we briefly state what QFD is and how it is used by total quality management (TQM) organizations. For more details see Hauser and Clausing (1988), Vasilash (1989) and Akao (1990).

QFD is a method used to identify critical customer attributes and to create a specific link between customer attributes and design parameters. It helps marketing and design to answer three primary questions: (1) What

attributes are critical to our customers? (2) What design parameters are important in driving those attributes? And (3) What should the design parameter targets be for the new design?

Market driven companies having a sharp customer focus produce designs that are responsive to customer needs and expectations. Most importantly these designs must be producible with minimum of inter-departmental conflicts. We therefore need procedures for listening to the customer and translating them into finished product realities. QFD provides a cross functional approach which uses a planning tool called "House of Quality" for organizing and linking the customer survey information with the product design attributes and later deploying it in stages throughout the organization. Customer feedback is used by the QFD team to make engineering, marketing and design decisions. Each step in the QFD process involves building up a section in the house of quality matrix thereby simplifying the presentation of a large amount of data. The steps involved in building the house of quality are: (i) identifying customer needs through market survey (ii) identifying customer counterpart product characteristics, (iii) relating the customer attributes to product characteristics, (iv) evaluating product characteristics and developing targets, (v) evaluating products of competitors by performing internal as well as external comparisons, and (vi) determining which product features to deploy throughout the production (or construction) process. The matrix comprises of the following sections (see Figure 1):

- A WHAT section
- A HOW section
- A WHAT - HOW relationship section
- A HOW MUCH section
- A CORRELATION section (roof of the matrix)
- IMPORTANCE RATINGS section
- A CUSTOMER ASSESSMENT section
- An ENGINEERING ASSESSMENT section

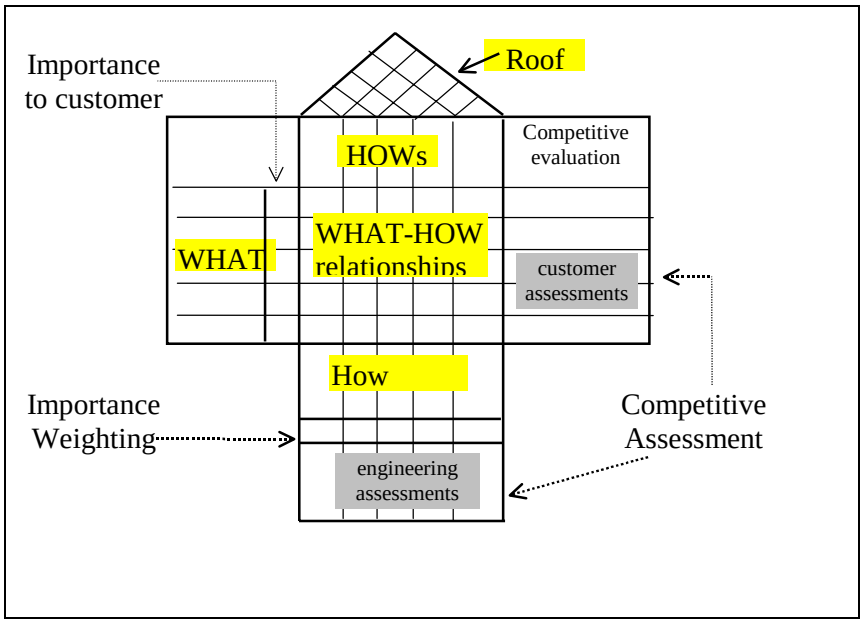


Figure 1: House of Quality Matrix

Several houses of quality are required in *deploying* the voice of the customer throughout the organization. QFD will be most effective if we take a systems-approach to implementing quality practices in the construction industry. It provides several benefits, such as, improved quality, reduced engineering changes, reduced product development time, lower start-up costs, lower design and manufacturing costs, reduced warranty claims, greater cooperation and teamwork between departments and a well-documented project history and information base. The HOQ provides a lot of customer and process-focused information that facilitates better decision-making while launching a house-building project. It helps translate the voice of the customer into the language of the engineer. The development of a manual HOQ matrix, however, consists of several non value-added steps. Such non-value adding activities may hurt

efforts aimed at promoting teamwork within organizations. These steps can be eliminated in an automated HOQ development process.

Note that early involvement in the product development process with the help of cross-functional teams is an absolute necessity to prevent problems downstream. **Cross-functional teams (CFT)** are an effective means for allowing people from diverse areas within a construction organization (or even between organizations) to exchange information, develop new ideas and solve problems and co-ordinate complex projects. CFTs provide benefits, such as, (a) faster completion of projects, (b) faster resolution of conflicts, (c) joint ownership of decisions, (d) better inter-functional communication, and, (e) improved sharing of knowledge and skills.

The Indian housing industry comprises of activities which are to be performed with the co-ordination of different categories of suppliers of materials like sand, cement, coarse aggregate, marbles, steel, timber, paints, electrical accessories, plumbing materials and equipments of different nature (i.e. mixers, vibrators, floor polishing motor, cranes etc.) In the manpower head, different types of skilled manpower like rod binder, masons, carpenter, plumber electrician are required. Besides, there are complex interactions between several organizations, such as, funding agencies, government regulatory bodies, consulting outfits and project management teams. Therefore, teams are the primary organizational mechanism needed in housing industry to implement total quality management initiatives.

QFD teams being cross-functional in orientation, effectively support concurrent engineering practices. However, the difficulty faced by Indian organizations is of a different nature. With the economy opening up the industry is faced with world-class competition. Organizational changes are inevitable to retain customers who are finding better alternatives in a market that has suddenly gone global. Organizations are at a problematic transition phase where the work-culture needs to be transformed from a somewhat reactive orientation to a more proactive culture. Most organizations are forced to go through a rapid transformation where stages in a process that are more sequentially arranged have to be scheduled in parallel. Unfortunately, the Indian industry (mostly the Public sector) has been extremely slow in realizing the urgency of this need to change. With reference to our context here on product design and development, concurrent engineering practices (as pursued by World Class Manufacturers) impose a lot of proactive involvement by bringing all downstream concerns up-front. Similarly, building robust designs is a highly proactive function that needs a rather radical change in most of these organizations. In addition, the CFTs have to overcome problems of bringing together geographically distributed teams and personnel. Change initiatives promoting cross-functional orientation could be faced with a resistance that may not be easy to handle. This resistance becomes even more intense if the computer-based tool that supports cross-functional product design and development is found to be ***user-unfriendly***.

We intend to develop a user-friendly front end to assist various cross-functional teams engaged in product development initiatives in the housing industry. Problems related to physical separation of personnel can be overcome through **virtual collocation** made possible by developing software that complement the advancements in Information Technology. *Our research focuses on automating the development of the House of Quality matrix, while attempting to foster virtual collocation through web-enabled technology, thereby enabling richer cross-functional interaction for supporting quality function deployment in the housing industry.*

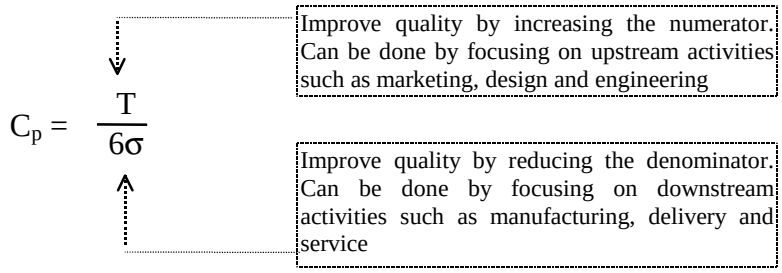
3. THE HOQ FOR SUPPLY CHAINS: A CONCEPTUAL FRAMEWORK

In the earlier section we realize the importance of the deployment process for providing *value* to the customers. Johansson et al (1993) define VALUE as (QUALITY*SERVICE) ÷ (COST*CYCLE TIME). Where:

QUALITY = meeting customer requirements, process integrity, continuous improvement etc.
SERVICE = product & customer support, flexibility to customer needs etc.
COST = design & engineering, conversion, distribution, administrations etc
CYCLE TIME=time-to-market (concept to delivery or order entry to delivery)

This section introduces our proposed framework. In quality driven organizations value addition is an on-going proposition. Such organizations prefer to measure value by monitoring the process capability. Thus value is linked with process capability, which is the ratio of the "voice of the customer" to the "voice of the process". In short, the voice of the customer, if translated properly, provides the tolerance specifications needed in satisfying customer requirements. The process control limits for any stable process provide the limits to the natural variation of a

process. This is the voice of the process (or the characteristic of that particular process). These natural variations are due to common (or random) causes. The capability of this process in meeting the customer requirements can be quantified in the form of a *process capability index* (C_p). Now,



Note that higher the index the better is the process capability. It means that the natural variations are too small and the specified tolerance is large enough for the process to meet the customer requirements consistently. TQM organizations aim to improve the process capability index by simultaneously managing both the numerator and the denominator of the above ratio (i.e., by making it an ***organization wide approach***). The challenge lies in extending this beyond the organization, which leads us to handling various supply chain priorities. Undertaking process capability studies for the entire chain becomes a formidable task.

As we know, all members along the value chain contribute towards the quality of the end product. Hence it is important to consider other key members of the chain while deploying the voice of the customer. For maximum satisfaction, however, the voice of the customer needs to be properly deployed *throughout the value chain*. This is not possible if we limit the deployment process within the boundaries of the organization.

To minimize distortions in transmission we require several houses of quality. Figure 2 presents a conceptual model as applied to generic supply chains, which is being tested in the housing industry in our study. The initiating organization is the focal organization [Figure 2] within the supply chain. The focal organization collects the voice of the customer and deploys it to the various upstream as well as downstream supply chain members through an effective **feedback mechanism**. A good feedback system helps the provider in knowing the preferences of the customer and continually striving to provide more and more value to the customer. Thus, an effective feedback mechanism helps build a ***learning relationship*** that can assist the provider in mass-customizing its products (or services) for the appropriate end user on a continual basis. A provider, therefore, is able to know the preference of its customers and provide the appropriately customized product or service. Such providers try their best to find the right product for the individual customer rather than finding the customer for their products or services. Pine, Peppers and Rogers (1995) have stressed the emphasis on having Customer Managers rather than Product Managers. According to them *"the customer manager's role is finding products for the customers, not customers for products."* In order to do that, the provider should develop the ability to elicit information about customers. With a learning relationship emerging, the provider can customize his/her offerings to provide value to the customer. Thus a good feedback system can move the organizational capabilities towards higher levels of mass-customization. In our research we are developing software capabilities to elicit customer wants and strengthen the feedback mechanisms. The following two sections briefly present our efforts aimed at supporting the conceptual model. The aim is to help virtual collocation of physically distributed teams.

4. AUTOMATED HOQ FOR SUPPORTING CFTs

Though the importance of having teams working on product development activities is understood it is often not easy to bring in a work culture based on team spirit. Hence the value of problem solving in cross-functional settings is not easily realized in many organizations. Even though QFD does provide the means to facilitate cross-functional decision making, the efforts to capture and present the information in the form of a planning matrix often might impede flow if done manually. It is important to understand that developing the HOQ is actually a means to an end. Actual interpretation of the HOQ matrix allows managers to make better decisions by providing them with a lot of information related to internal and external benchmark parameters. Decision-makers therefore need to be freed from the cumbersome task of *constructing* the HOQ matrix. Instead, automated systems can be used to capture data, analyze and present the information as quickly and efficiently in the form of a HOQ matrix. Also like other decision

support systems (DSS) the aim should be to create a software model that allows its automatic generation at the same time eliminating all possible non-value added activities. In a manual system the development of the HOQ matrix is rather cumbersome. It has several non value-adding stages, which can be eliminated in a computerized system. The proposed research is aimed at eliminating such stages through the development of appropriate software.

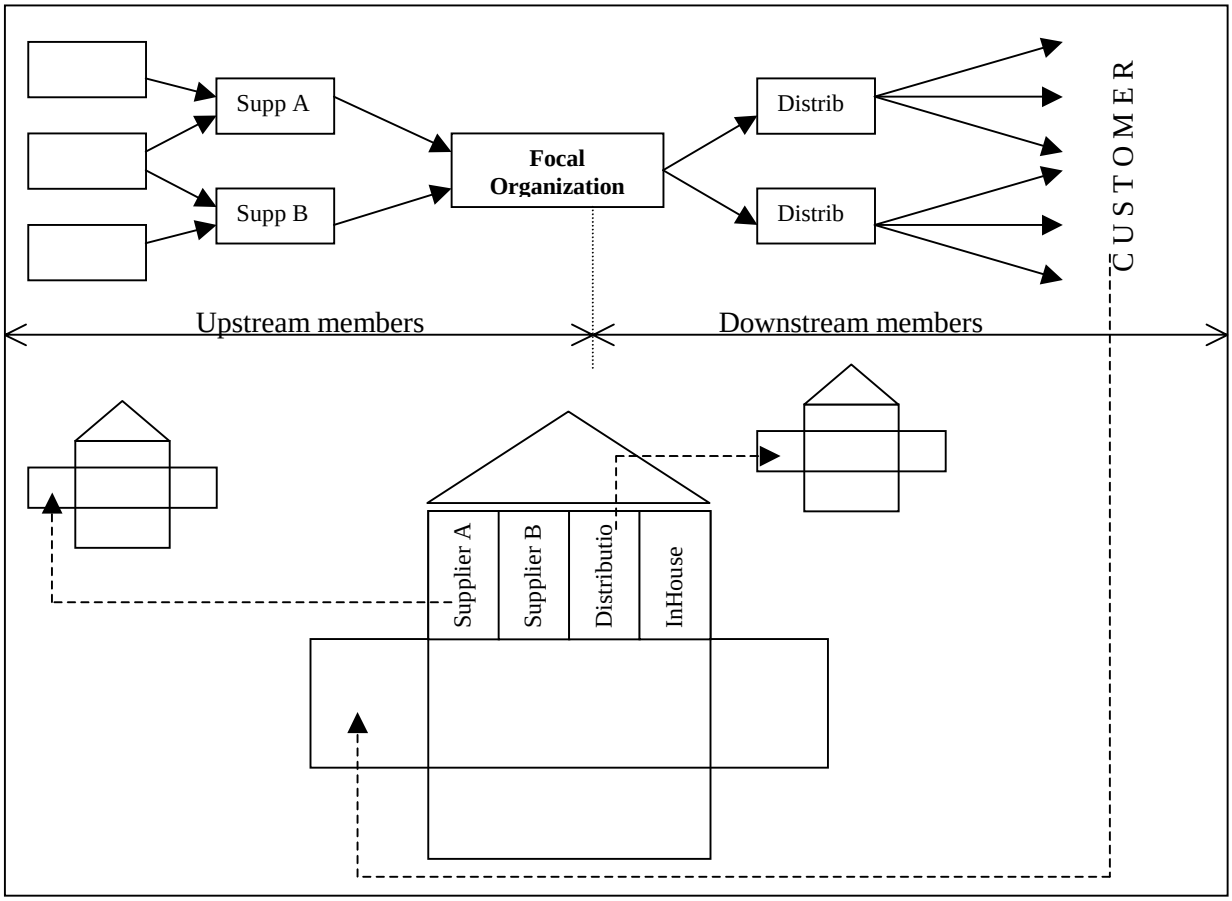


Figure 2: Using the HOQ for a Generic Supply Chain

Liu (1998) has developed an intelligent HoQ to relieve users of all calculations involved in developing HoQs manually, detect implicit trade-off and impact relationships and maintain their consistency based on fuzzy logic, while enabling automatic archival and management of HoQs based on a database system. Sahu (2000) and his associates have demonstrated the need for having an automated house of quality generation software for enhancing inter-departmental collaborative relationship. Such software can overcome the adversarial relationships between departments by presenting cross-functional data in a distributed environment. Since QFD involves the development of HOQ matrices, it becomes a cumbersome task to present the information for organizations dealing with hundreds of customer attributes. Hence to make it more acceptable by the Indian Industry they have developed a proof-of-concept program to demonstrate the utility of such tools for rapid product development. Indian industry has the indigenous capability to develop and implement such software meant for enhancing product development activities.

We realize the need for extending the capabilities of the above software beyond the organizational boundaries while customizing it specifically for the housing industry. Such systems can facilitate effective communication between important supply chain members. Figure 2 shows how the initiating organization can provide support for early involvement of partners in the product delivery process. For instance there are several customer attributes that can be satisfied by the distribution function. The distribution channel partner needs to be informed of these requirements so as to effectively satisfy the customer wants. We envision a system where the software capabilities can be extended to overcome adversarial relationships between chain members. Bowen and Brown (1997) have demonstrated examples of QFD applications under similar settings. Their system, GIDE, fosters product development under cross-organizational settings.

5. ROBUST DESIGNS FOR SUPPLY CHAINS

Efforts are also on to enhance the capabilities of the proposed software to further support the development of robust designs for supply chains. As we know, the primary aim of any "Design for X" methodology is to assist the designers (either experienced or inexperienced) by addressing up-front as many of the downstream concerns as possible. Much progress has been made in this area since the early eighties. While the earlier systems were aimed at breaking the barriers between design and manufacturing, the present day systems have made a lot of progress by extending the concept to a much larger span within the value chain. Today we have systems aimed at addressing environmental considerations. Thus design-for-environment is of growing significance to the industrial community.

One of the design-for-X methodologies of significance to supply chain research is that of design-for–logistics. Various product and process design initiatives [Lee 1992, Davis 1993, Feitzinger 1997] have been taken in this direction to eliminate key product cost drivers. Companies are continually seeking opportunities for converting sequential stages to concurrent and parallel processes. Some have attacked packaging and transportation costs to help reduce logistics costs. Researchers have also helped unleash the potential of strategies that encourage postponement and delayed differentiation.

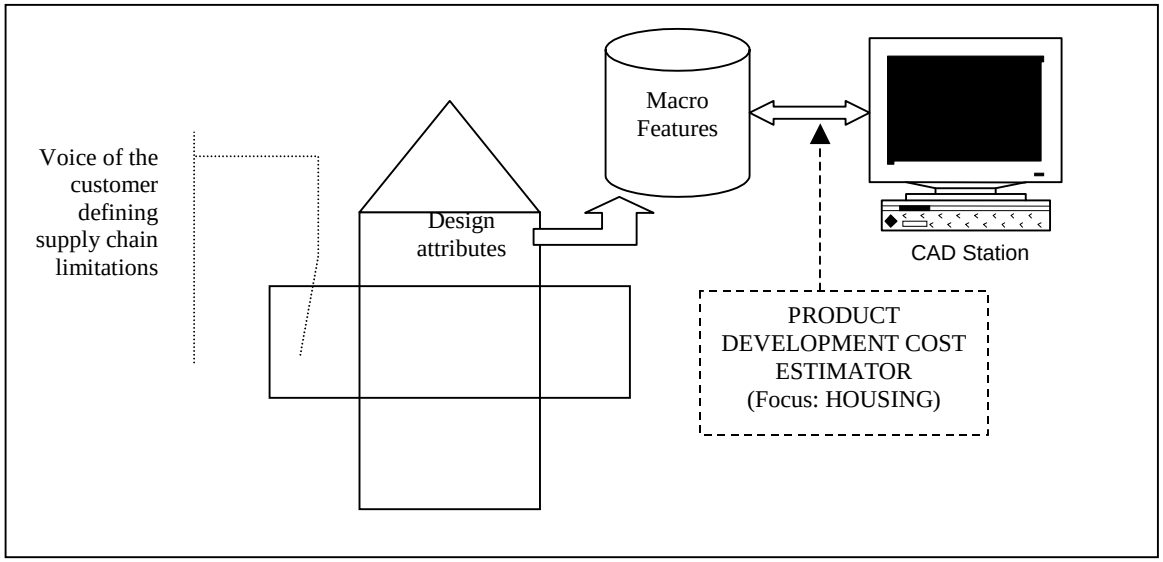


Figure 3: Linking HOQ to CAD Software

Though attempts are being made to overcome supply chain limitations we need more front-end support for aiding designers to design products from a broader perspective. Wood et al. (1997) have used an innovative tool for gathering customer preferences in the product design process at Volvo without using physical prototypes. In our research, we propose to link the house of quality matrix to CAD tools for generating products based on the customer specified attributes. A features library can be used for linking the information compiled in the HOQ matrix with various CAD models [see Figure 3]. These virtual prototypes will help prune the design alternatives early in the design development cycle.

Sahu and Grosse (2001) present a framework for preserving the design intent for supporting several other non-manufacturing activities within the value chain. There are activities in marketing that are meant to guide the customer through the concept space. However, because of the lack of domain knowledge, this activity is not performed effectively. This framework supports such activities where the user is allowed to participate right through the concept development stage. It provides a user-interactive front end where the customer can pick up the various features that can be combined to develop specific configurations. It will help guide the customer through the concept space for further enhancements of the product. It is meant to provide guided search mechanisms and promises to reduce non-value added time by eliminating aimless wandering in the concept space. It lends effective support to marketing teams for conveying the design intent. It also allows customers to properly use the design features which

otherwise would have been made redundant due to the lack of domain specific knowledge (or awareness). Efforts are on to apply this work to the housing industry as one of our application test-bed. A product development cost estimator that has been developed here will be also linked to this framework as shown in Figure 3.

6. CONCLUSION

In this paper we present our proposed line of research. We have emphasized the need for having cross-functional teams engaged in various product development initiatives. We have presented a framework that can be adopted for facilitating collaboration between supply chain members. The proposed research is aimed at developing virtual prototyping capabilities by linking the HOQ planning tool with CAD software. Another line of research is aimed at assisting collaborative teams to design robust supply chains under uncertain and disastrous natural environmental effects. We welcome collaborative support in carrying this work forward.

7. ACKNOWLEDGEMENT

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