Constructing a *Customer Science* Application System *"CS-CIANS"*
- Development of a Global Strategic Vehicle *"Lexus"* Utilizing *New JIT* -

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Abstract: A future successful global marketer must develop an excellent quality management system that impresses users and continuously provides excellent, quality products in a timely manner through corporate management. As providing what customers desire before they notice their wants will become a more essential part of any successful manufacturing business, the author constructs a *Customer Science* application system *"CS-CIANS"* by utilizing *New JIT*. For strategic product development, the author develops "TDS–DTM" as a core-element "TDS" of *New JIT,* which contributes to the excellence profile design to *"Lexus"*.

Key-Words: Customer Science, Studying Customer Value, *CS-CIANS*, *New JIT*, TDS-DTM, *Lexus*, Toyota

1 Introduction

Customers normally react positively or negatively to existing products. However, in many cases, they do not have a clear idea of their future desire. Therefore, Sales and service personnel are the closest to the customers. When they convey customer needs to R&D and design division staff, whose languages are objective and numerically minded, scientific language rather than implicit language should be the common language. Furthermore, product designers must accurately interpret the customer's voice that expresses their needs and develop an optimal drawing. As providing what customers desire before they notice their wants will become a more essential part of any successful manufacturing business, the author proposes *Customer Science* [1,2] with the application of *New Just in Time* (*New JIT*) [3] for studying consumer values.

CS-CIANS (*Customer Science* utilizing Customer Information Analysis and Navigation System) [2] is proposed. This is designed to analyze customer information incorporating the optimal scientific approach, *Science SQC* (Statistical Quality Control) [4], and to serve as a navigation system for the acquired analysis results. The effectiveness of this network system will then be verified. Furthermore to verify the validity of *CS-CIANS*, the author develops "TDS-DTM" (Toyota Development System - Design Technical Methods) [5] by using *Customer Science*, which contributes to strategic product development. *Customer Science* has achieved a given objective by pursuing studies on applying the above methodology to the excellence profile design of vehicles *"Lexus"*. The market reputation of the *"Lexus"* in Japan and overseas has demonstrated the validity of "TDS-DTM", a strategic model of product development as the key to *New JIT*.

2 Need for a New Management Technology Principle

The production technology principle Japan contributed to the world in the latter half of the 20th century was the Japanese-style production system typified by the Toyota Production System (*TPS*) [6], enhanced by the quality management technology principle generally referred to as Just In Time (JIT) [7]. Today, however, improvements in the quality of Japanese-style management technology principles are strongly desired in the face of unexpected quality-related recall problems breaking out among industrial leaders, while at the same time delays in technical development cause enterprises to experience crises of existence [8,9].

To realize manufacturing that places top priority on customers with a good Quality, Cost and Delivery (QCD) and in a rapidly changing technical environment, it is essential to create a core principle capable of changing the technical development work processes of development and design divisions. Similarly, it is important to develop a new production technology principle and establish new process management principles to enable global production [10,11]. Furthermore, new marketing activities independent from past experience are

required for sales and service divisions to achieve firmer relationships with customers. In addition, a new management technology principle linked with overall activities for higher work process quality in all divisions is necessary for an enterprise to survive [11]. In this need for improvements, Toyota is no exception.

3 *Customer Science*, Studying Consumer Value Utilizing *New JIT*

3.1 *Customer Science* Principle

Supplying products that satisfy consumers (customers) is the ultimate goal of companies that desire continuous growth. In this new century in which the global marketing of products is the basis of management, it is necessary to manufacture products that bring increased value to customers in addition to matching the life stage and lifestyle of each customer. In order to develop and provide attractive customer-oriented products to attain this purpose, the current problems are researching customer needs and establishing visionary strategic product design methods [2].

Customers generally evaluate existing products as good or poor, but they do not generally have concrete images of products they will desire in the future. For new product development in the future, it is especially important to "supply desirable products before customers desire them". For that purpose, it is important to precisely understand the vague desires of customers. Proposal of *Customer Science* principle [2], shown in Figure 1, makes it possible to concretize customer desires. It is intended to indicate the desirable state of new business processes for creating "wants" indispensable to the development of attractive products.

As shown in the figure, the image of customer's words (implicit knowledge) is translated first into common language (lingual knowledge) and then into engineering language (design drawings as explicit knowledge) by means of appropriate correlation. In other words, objectification of subjective information is important for future product development. It is also important to transform objective into subjective information (subjectification) through correlation to check that engineering successfully reflects customer requirements. An approach based on customer science methodology will make product planning and uncertain business processes more accurate, possibly increasing success rates and decreasing failure rates.
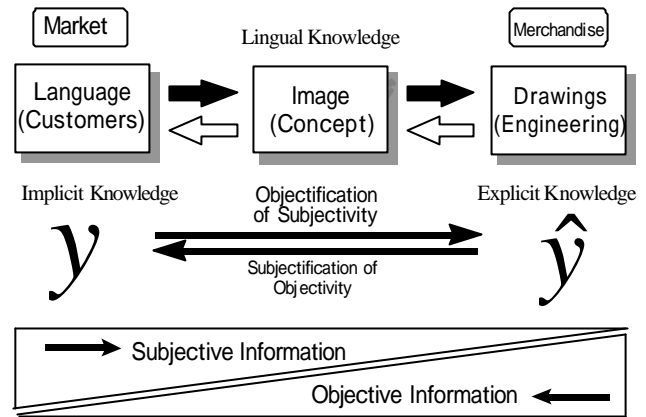

Fig.1 Schematic Drawing of *Customer Science* principle

3.2 Strategic Implementation of *New JIT*

In this age, information technology (IT) development has led to a market environment where customers can promptly acquire the latest information from around the world with ease. Customers select products that meet their lifestyle and a sense of value on the basis of a value standard that justifies the cost. They are strict in demanding the reliability of enterprises through the utility values (quality, reliability) of products. It is therefore apparent from recent scandals and recalls that enterprises will be dismissed from society and/or the market if they fail to evolve their quality management on a customer-first basis by using *Customer Science*. For the reason stated above, the author [3] proposes a new model of business management technology called *New JIT* by using *Customer Science* as shown in Figure 2, for use as a next-generation production methodology.

The primary aim of *New JIT* is to use *hardware and software systems* to strengthen management technologies into a next-generation management strategy. The hardware systems utilized are *TMS* (Toyota Marketing System), *TDS* (Toyota Development System), and *TPS* (Toyota Production
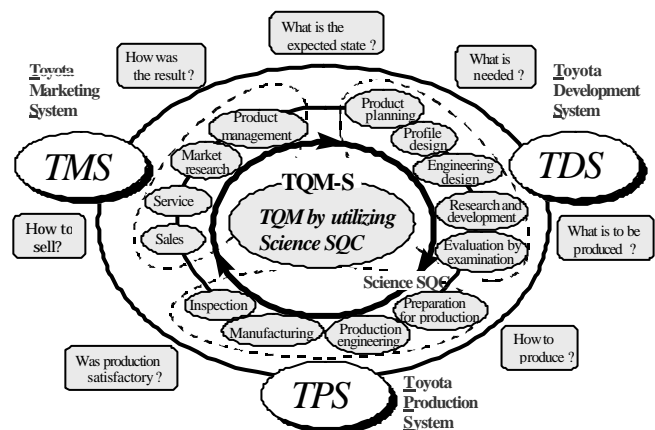

Fig.2 *New JIT*, Management Technology Model

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System). These three core systems are indispensable for establishing new management technologies in the marketing, sales, development design, production engineering and manufacturing divisions.

The author [1,3] proposes TQM-S (TQM promotion utilizing *Science SQC* called *Science TQM*) as the software system utilized in strategic quality management. The aim of this system is to improve the quality of business processes in the 13 divisions shown in the figure. In this way, the author has tested the effectiveness of the "strategic model of new management technologies" at Toyota for the further advancement of *JIT*.

4 Constructing a *Customer Science* Application System "*CS-CIANS*"

4.1 New Model for Assisting the Conception of Strategic Product Development [2]

Today, growing companies both in Japan and abroad try to grasp the unprejudiced desires of their customers from the viewpoint of customer-oriented business management and to reflect these desires in future product development. However, the actual behavioral patterns (conception methods) of designers (new product planners and designers) in trying to grasp latent customer desires depend heavily on the designers' empirical skills. Designers often proceed with product development using implicit business processes.

Accordingly, their performance is measured by sales results and their efforts to improve business processes for future jobs may be insufficient as implicit prescriptions. Designers often worry that their current business approaches are likely to depend on job performing capabilities and on the sensitivity (intuition or knack) of individual persons,

which will not improve the probability of success in the future, regardless of whether or not they have "lucky success" or "unlucky failure". It is, therefore, important to establish a scientific approach that improves powers of product conception sight and foresight) or a "new model for assisting the conception of strategic product development" and to test its validity.

For the realization of strategic products, the collection as well as intellectual analysis of customer information for creating customer "wants" is the core essence for success in *Customer Science.* Table 1 shows the levels of systematic utilization of customer information and the modes of intellectual information-sharing among the related divisions inside and outside the company that are necessary to achieve this objective [2]. In order to advance the level of execution of *Customer Science* activities, it is necessary to evolve customer information-sharing among the Marketing/Sales/Service, Product Management/Design, and Engineering/Production divisions from off-line to on-line[11].

4.2 *CS-CIANS*, a Networking of the *Customer Science* Application System

For strategic product development, it is important to explore consumer values, which are the basis for creating "wants," through the collection/analysis of customer information, and to reflect as well as exteriorize such values in product development. Against this background, *CS-CIANS* is proposed, as shown in Figure 3. This is designed to analyze customer information incorporating the optimal scientific approach, *Science SQC*, and to serve as a navigation system for the acquired analysis results. The effectiveness of this network system will then be verified.

Figure 3 shows the *CS-CIANS* networking system to which the customer science method is

Tabel.1 Systematic Utilization Levels of Customer Information for *Customer Science* Activities

Div. / Level	Marketing, sales and service	Product management / Design		Engineering divisions	Overseas
5	Collecting information overseas for shared use				
4	Information sharing between divisions				
3	**Advanced *Customer Science* Level**			Unifying plan concepts based on shared information	Analyzing customer information for reflection in overseas business
2		Requesting and reporting (viewing) on the Web	Reflecting customer information analysis on sales and service		
1	Requesting and reporting (viewing) in writing		*New business process for creating "wants" indispensable to the development of attractive products*		
Operation	Intellectual Implementation of *Customer Science* by using scientific analysis approach				
Online	On-line use possible				
	Intelligent on-line use possible				

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applied. As indicated therein, this system enables (1) the Merchandise Planning Div. which explores customer values and (2) each division of Product Planning and Design to regularly receive "Customer Data" from (3) domestic and overseas dealers which are exposed to the front line of the customer desires through their marketing/sales/service activities. Similarly, the collection of "Customer Data" is also possible through (4) Consulting Spaces, namely, the showrooms promoting the company's own products or public facilities for discussions and consultations from the customers. Moreover, (5) the domestic/overseas marketing research companies (Research) conducting analyses of market trends and customer preferences are also a source of information for feeling out customer values.

All these sections are connected through on-line networking for building (6) a Database via a dedicated server of the company's own information system division. Into this system, (7) the core system of SQC integration network system, *TTIS* (Total SQC Technical Intelligence System) [12], namely, *TSIS-QR* (Total SQC Intelligence System for Quick Registration and Retrieval Library) [13], which has been developed by the author and others and already utilized by Toyota and group companies, is incorporated so that registration or search of customer information can be carried out in real-time using the data input/output form.

Another feature of *CS-CIANS* is that the Merchandise Planning & Design division can conduct in a timely manner market investigations of the company's own products as well as

benchmarking of competitors through cooperation with (3) Dealers, (4) Consulting Spaces, and (5) Marketing Research Companies via (8) an exclusive company WEB. In particular, it can carry out an SQC analysis of the acquired data by incorporating (7) "*TPOS*" (Total TQM Promotional Original SQC Soft) [12], that is, the second core system developed by the author and others for creating "wants." In practice, an advanced analyzer skilled in SQC analysis (Expert) gives instructions to an inexperienced analyzer "Beginner," while collaborating with mid-level analyzer "Intermediate analyzer" who has a certain level of experience [4].

What serves as the guide for this scientific approach is the core system of *TTIS*, such as (7) "*TSML*" (Total SQC Manual Library) [12], the guidebook of SQC analytical results, and (7) "*TIRS*" (Total Technical Information System) [12], the technical references and reports. These are accessible for search and utilization from (9) Analytical Case Data Base (DB). As seen in the diagram, each of the data consists of (i) an A4-sized cover page with overview summary (Cover), (ii) step flow charts of SQC analytic processes on the sheets of the same size, called "Flow charts", and (iii) the main contents of the report on customer information analysis "Report", designed with high user-friendliness.

Particularly for highly complicated customer information analysis or advanced SQC analysis, cooperation requests for analysis can be submitted to (10) a "Special Adviser" in an exclusive SQC analysis division, the "Special Analytic Div." The
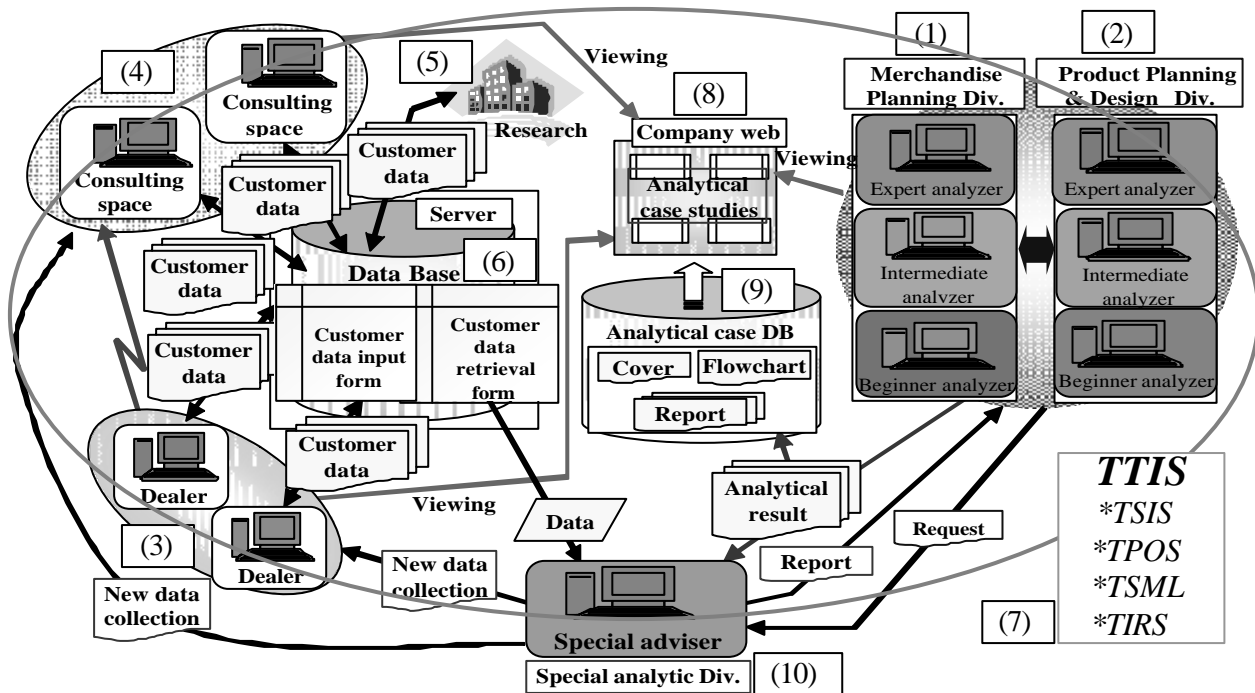

Fig.3 *CS-CIANS*, Networking of *Customer Science* Application System for Strategic Product Development

system is designed in such a way that the collection of "Analytical Results" created by (1) Merchandise Planning, (2) Design, and (10) exclusive SQC analysis division are registered and kept in (9) Analytical Case CB for the successive development of analytical technology [4].

5 Application
-Development of *Customer Science*, Key to the Excellence Design "*Lexus*"-

5.1 *Lexus* Design Profile Study by Utilizing Psychographics
During the development of a model-change vehicle, keen attention is paid to changes in the design in addition to selling points strengthened through functional improvements [14]. Actually, it can be said that the appearance of a vehicle or the design is of high importance when customers decide which one to buy. The reason consumer goods such as vehicles can sometimes be purchased on impulse is that customers are impressed with and attracted by their designs. Psychographics of automobile design profile refers to obtaining an appropriate outline profile (proportion), which is the skeleton of an automobile, by scientifically studying the relationships between the profile and psychological factors in the development stage so as to match the customer' feel (sensibility). As a scientific approach, *Science SQC* is applied from the viewpoint of *Customer Science* [15,16].

5.2 Development of "TDS-DTM" Utilizing *New JIT*
The authors [2,5,15,16] think that the analysis process itself that turns implicit knowledge named designing into explicit knowledge constitutes the secret to the conception. In this connection, the author develops "TDS-DTM", the conception support method for developing strategic product quoting the "SQC Technical Methods", which is a core method of the *Science SQC* in Figure 4. This diagram signifies implementing *Customer Science* for turning the design process into an explicit knowledge as more creative activities from the implicit knowledge of designing.

The authors will attempt to carry on the "bridging" portion in the course of realization of strategic product designing from the mainly research-oriented analysis as the event analysis according to the business process (Step 1 to Step 2 to Step 3 in the diagram) shown in Figure 4. This methodology is intended to establish a new

methodology for supporting conception, which will ascertain the field covered by conception adapted to the times and contribute to enhancing the proposal capability of designers. In the following, the authors will expressly show the utilization process of the "TDS-DTM" proposed and demonstrate its validity through cases of application studies.

In the following, the application process of "TDS-DTM" for the product development of a new model of "*Aristo/Celsior* (U.S. name: *Lexus* GS400 / S430)" be described in the sequence of Step 1, Step 2 and Step 3 of Figure 4. In these connections, the authors confirm the development of *New JIT*, the key to the excellence design "*Lexus*".

5.2.1 Studies on Customers' Sense of Values Using Collages (Step 1)
A collage is something created by gluing various materials on a picture surface. It is a design process for creating images as represented by Picasso [17] with his work (*Still Life with Chair Caning*, 1912); such a work is called a collage panel. Upon designing a global strategic vehicle "*Lexus*", the matter of primary concern for the designer is how to catch the target customers' heart.

For the present time, the authors use collages created by the designer and search for coincidence with the designer's images by investigating the customers' sense of values scientifically using the following methods:
(1) Creation of collage panels for researching design images
  Types: (An image by the designer) A: Ethnic (Soft), B: British (Traditional), C: German (Artificial), D: French (Natural), E: Japanese (Ceremonial), F: Italian (Casual)
  Composition: Decorative accessories, Watches, Rooms, Interior decor, Gadgets, Clothing
(2) Questionnaire with customers for image survey by generation
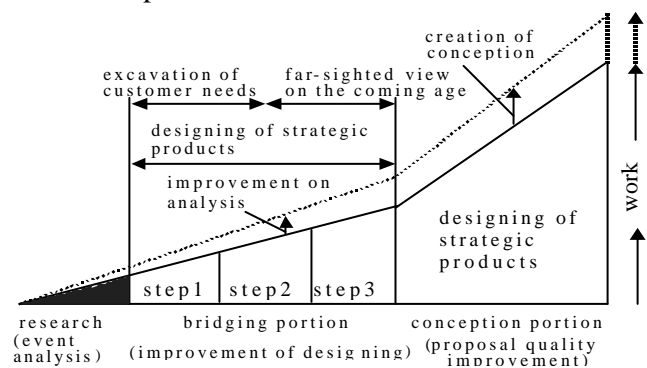 Example: 372 Japanese subjects selected with an assumption of domestic sales

Fig.4 "TDS-DTM", the Conception Support Methods for Developing Strategic Product

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Generation: The name of the generation, the age, the number samples and the origin of the name are as follows:

- (a) Cinema generation (19 people aged 56 to 65); When they were in the bloom of youth, the movie industry was also in the golden period and in the center of the youth cult.
- (b) "Baby-boomers" (30 people aged 50 to 55); Their generation presents the maximum population in the post-war period.
- (c) "DC-baptized generation" (53 people aged 43 to 49); This generation is characterized by zeal for by wearing fashionable DC (designer and character) branded clothes.
- (d) "New humans" (called "Shinjinrui") (52 people aged 37 to 42); When they were young, they were thought "eccentric" by an adult.
- (e) "Bananas" (90 people aged 31 to 36); This generation tends be sensible and prefer moderate personality. Sensuous characters in the work of the Japanese novelist, Banana Yoshimoto are typical of this generation.
- (f) "Baby-boomer juniors" (128 people aged 25 to 30); This generation is the children of baby boomers.

Implementation of questionnaire: (subjects selected at random)

Out of the image-expressing design terminologies, the designer extracts 24 "image words" (such as 1.Elegant, 2.Cute, 3.Approachable, 4.Delicate, 5.Tasteful, 6.Fine Sense, 7.Refined, 8.Calm, 9.Intellectual, 10.Traditional, 11.Adult, 12.Orthodox, "13.Simple, 14.Urban, 15.Advanced, 16.Bold, 17.Powerful, 18.Energy, 19.Light, 20.Sporty, 21.Future, 22.Luxurious, 23.Youthful, and 24.Individuality) popularly used by designers and easily understood by people in general.

The subjects (I) select image words (multiple answer) they associate with the panel presented, and (II) rank the panels in the order of their preference (1st place: 6 points, 2nd place: 5 points, 3rd place: 4 points, 4th place: 3Points, 5th place: 2 points and 6th place: 1 point).

(3) Analytical example of the "images of preferences by generation"

As an analytical example of investigating customers' sense of values, Figure 5 shows the result of analysis of the main component of the questionnaire (order of image word preference by generation). From this figure, the primary component axis is interpreted as modern/formal, the secondary axis as soft/sharp. A: ethnic, D: Italian, and F: French are positioned in the first quadrant, B: British in the second quadrant, E: Japanese in the third quadrant and C: German in the fourth quadrant.

In addition, according to the data given in the same diagram, the mean value of each group implies the general characteristics of each group as follows: the "bananas" and "new humans" tend to like panels A, B, D and F, the "baby-boomers" and "DC-
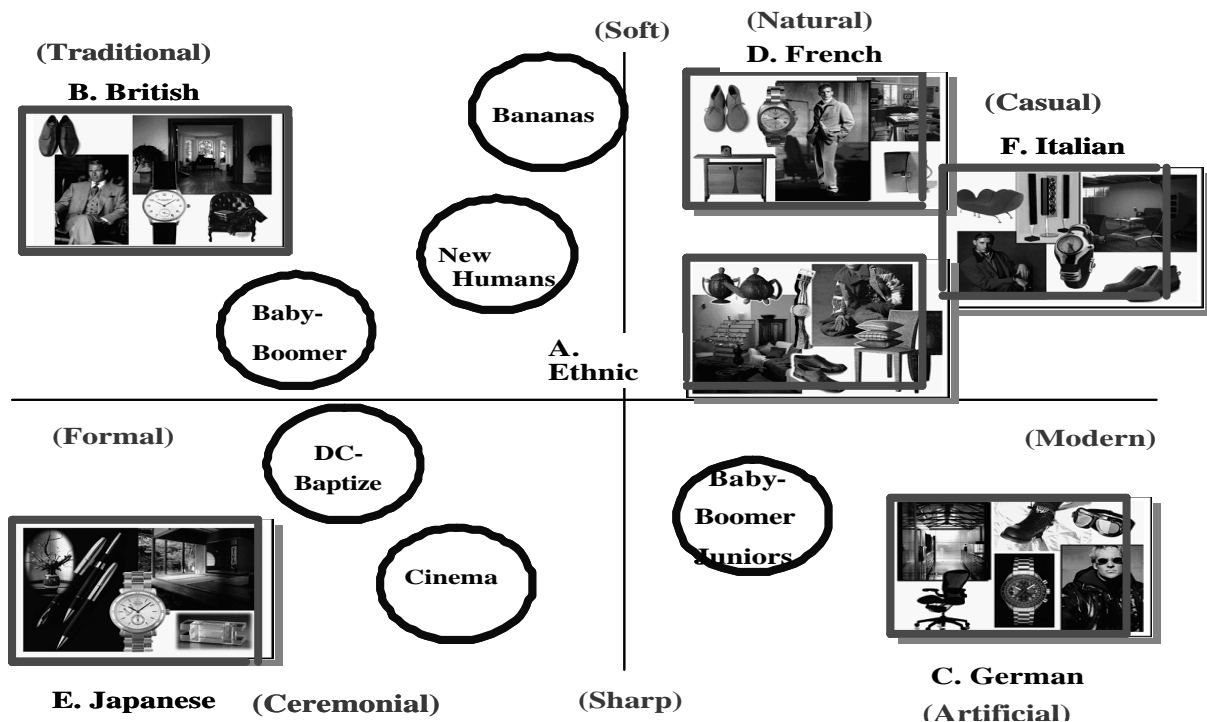

Fig.5 Collage Panel Image Analysis by Generation

(Principal Component Analysis/Correlation Method: Scatter Diagram of the Principal Ratings)

baptized generation" tend to like B and E, the "cinema generation" like E, and "baby-boomer juniors" like C. However, (although not shown in the diagram) the above results were affected by the difference in the customers' lifestyle elements, and the preferences of a panel are widely spread among subjects of the same generation. The inside of the figure shows the dispersion of the taste with six collage panels of the baby-boomer generation and the image words. Similarly, the authors have found that the panel images of the designer coincide with the preferences of the consumers of the generation the designer belongs to but do not necessary coincide fully with those of other generations.

From these analytical results, (although not shown in the diagram) it is possible to surmise that the idea for developing strategic products can be born in two ways, namely, by the royal road to designing by using a designer of the same generation as that of the target customers, or by using a designer of a different generation from the target to create an appealing design from a new point of view. Based on these analyses, the authors study customer preferences for designing vehicle appearance as step 2.

5.2.2 Studies on the Customer's Design Preferences for Vehicle Appearance (Step 2)

It is a well-known fact that the design of vehicle appearance has considerable weight in the customer's decision to make a purchase. To which part of vehicle appearance design do customers, domestic and overseas (regardless of age and sex), pay attention? Professional automotive profile designers have a theory (rule of thumb) that in general, Japanese customers tend to focus on the front design while North American customers look at the overall design of front, side and rear. Our challenge here is to give an objective analysis on the theory. To the authors' knowledge, no report has been made for objective verification of the theory by research and analysis in the academic world.

Therefore, quantitative evaluation on the sections of vehicle appearance customers are interested in will advance a customer-in design strategy. For designing the new *Lexus GS400/LS430*" for model change, 157 customers (young and old, and male and female panels) of various personality are asked to evaluate the appearance of the four major, mutually-competing models (BMW 850i/1990 model, Benz 300-24/1989 model, Legend coupe/1991 model and Soarer 4.0GT/1991 model) and priority of the three appearance factors: front, side and rear views.

In analysis (1), the authors will verify the correlation between the evaluation and priority by multi-regression analysis. The three appearance factors are further divided into the design balance (profile) and detailed elements (4, 9, and 5 sections respectively) for a similar study on their causal relationships as analysis (2). A preliminary cluster analysis shows that the customers can be stratified in terms of the overall liking of the vehicle appearance into a group lower in age and annual income and a group higher in age and annual income in their personalities for all four models.

Figure 6 shows an example of analytical results on a vehicle model specified to the group higher in age and annual income. In analysis (1), the contributory factor adjusted for the degree of freedom (R^{*2}) representing the degree of influence to the overall evaluation of vehicle appearance (X1) is 0.62, indicating a high causal relationship. The breakdown is as follows: The influence of the front view is even higher at $Bfv=0.59$ while the influence of the side and rear views (X7 and X17) are relatively low at $Bsv=0.18$ and $Brv=0.17$ in analysis I. In analysis (2), the analytical results are similar to those for the group with lower age and annual income but the influence of bonnet (X4) is high on the front view (X2). It is verified that the vehicle appearance is evaluated in a wider range; for example, the influence of the line (X19) from the rear to the trunk and the design balance (X22) of the rear as a whole are high on the side view (X7). This analytical trend also applies to other three models.

On the other hand, in the group lower one, though not illustrated, in analysis (1), the overall
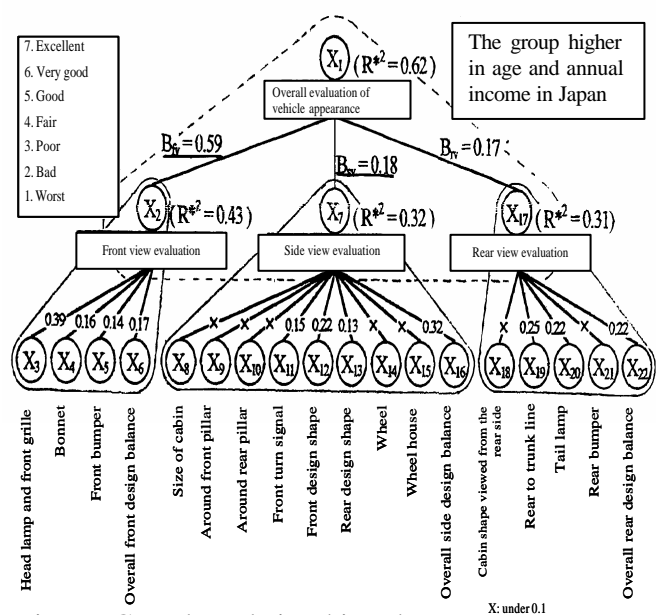

Fig.6 Causal relationship between customer satisfaction assessment and vehicle appearance assessment factors by multiple regression analysis

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evaluation of vehicle appearance (X1) is also 0.74, indicating a high causal relationship. The breakdown is as follows: The influence of front view (X2) is fairly high at Bfv = 0.46 while those of the side and rear views (X7 and X17) are at Bsv= 0.30 and Brv=0.29, showing their positive influences. In analysis (2), the head lamp and grille (X3) have a high degree of influence on the front view (X2) while the overall side view and design (X16) and tail lamp (X20) and rear bumper design (X21) exert much influences on the side view (X7) and rear view (X17) respectively. A similar survey and analysis are conducted in North American market. While the front view is generally high priority in Japan, it is known that the front, side and rear views are equally valued in North America.

Other noticeable input is that Japanese customers are likely to provide individual evaluation for each front, side and rear view at a dealer, while North American customers evaluate the front view while looking at a moving car on the opposite lane, evaluate the side view while looking at a car driving pass, evaluate the rear view similarly on the street. The authors confirmed that as they evaluate the three appearance factors, their focus is the total balance of the design. Through this analytical study approach, designers have understood the need for the customer-in design strategy that gives consideration to the characteristics of each country. These findings are the result of verification of the designer's theory (rule of thumb), which greatly contributed to the designing of the global strategic vehicle "*Lexus* GS400/LS430".

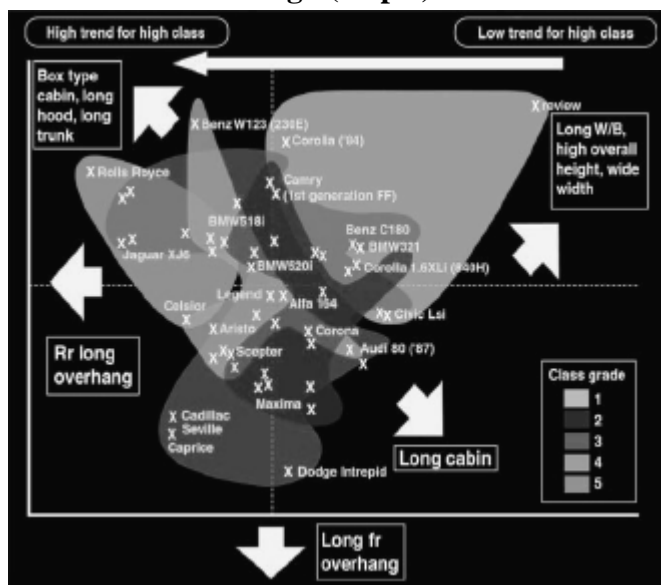## 5.3 Studies on the Psychographics of the "*Lexus*" Profile Design (Step 3)

In the product development stage, a process of modifying the appearance profile (proportion: ratio) to a scientifically legitimate profile that matches the preferences of customers based on the relationship of the contour and psychological factors is called "profile design psychographics". The significance of the present study does not lie in the trendy research of the "newness" of mere passing fad that places importance to the form and surfaces (round, square).

It is the development of explicit knowledge of "evolutional newness" demanded as a matter of course. It is most typically expressed with proportion. A principal component analysis was conducted on 62 domestic and overseas vehicle models. Their model years (year of introduction), classes (selling price) and proportions (hood ratio, luggage compartment ratio, cabin ratio, roof ratio, front and rear overhang ratios, wheel base ratio, overall height ratio, overall breadth ratio, and the roof/cabin ratio in relation to overall length were obtained autographically and their principal components were analyzed respectively by vehicle class (from class 5 for high class to class 1 for low class) and the year of introduction (three categories: before '86, '87 to '91, and '92 and onward).

When the scatter diagrams on these two principal components are overlapped as shown in Figure 7 and Figure 8, old, high class vehicles with a coach-type cabin (with long hood and luggage compartment length) such as the famous Rolls Royce, Benz W123, BMW518, Jaguar X16, etc., are laid in the second quadrant. In the opposite fourth quadrant, late-model vehicles with a long cabin and shorter hood and luggage compartment are positioned. From the results of these analyses, it has been quantitatively clarified that seemingly "highest
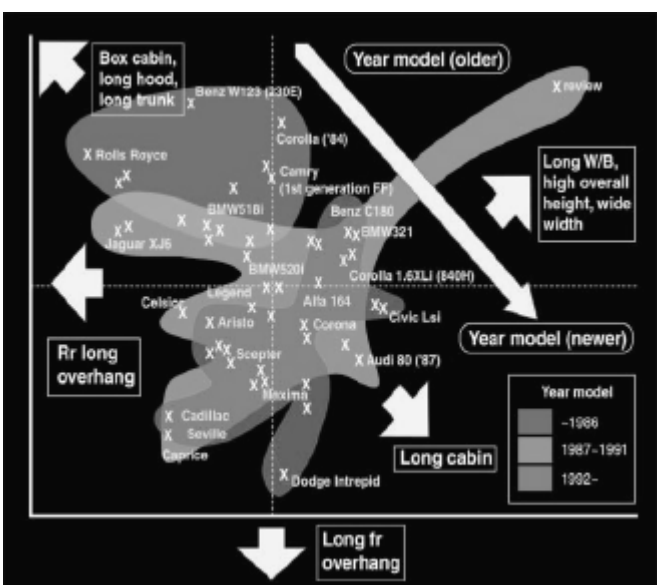

Fig.7 Classification of vehicle model by the class degree

Fig.8 Classification of vehicle model by the year model

class" and "latest" are mutually contradictory elements. The authors then identified the general rule (that was not the intentional but the natural consequence of designers' works) of the common proportional ratio (highest class) that is inherited in the world's prestigious vehicles and insusceptible to change over five or ten years. In addition to applying the general rule to the "*Lexus*" design profile, the authors manifested advanced form and surface to realize the combination of "highest class" and "latest" for "*Lexus*" design development.

With this study, the authors explicitly established the roles of the profile, form and surface. The authors also realized and embodied the combination of a profile of a reputable vehicle, advanced form and surface through the development of the "*Lexus* GS400/LS430*". The market reputation of the "*Lexus*" in Japan and overseas has demonstrated the validity of "TDS-DTM" [18,19].

6 Conclusion

This study discussed the effectiveness of constructing a *Customer Science* application system "*CS-CIANS*" *for* Strategic Implementation of *New JIT*. Furthermore, the author proposed the innovation of business process in developing and designing attractive product by "TDS-DTM" as the method to develop idea for strategic product development. "TDS-DTM" was applied to the study of "*Lexus*" profile design to enable the analysis of customers' value regardless of the nationality from the *Customer Science* point of view. This study played the key role to develop "*Lexus*" of which design profiles receive global popularity.

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