STRUCTURE VISUALIZATION IN DESIGN DEVELOPING PROCESS OF JAPANESE CAR COMPANIES

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Abstract: This study involved the car design development process by comparing an eleven Japanese car company’s design development process. Most Japanese car companies have huge design department and design-branches in abroad internationally. How do these companies manage design development across using multiple bases?

Firstly, each company’s development methods were gathered through interview with the general manager of the design department. As a result, the car design development process can be classified into four stages, "Advance Stage", "Concept Stage", "Main Stage" and "Tuning Stage". Secondly, role of diverse types design competitions within their design-branches and external design consultant were classified into three groups. Moreover, the design decision method can be divided into three groups, such as, "Consulted by the Project Team", "Decision by the Key Person", and "Entrusting to the Design Department".

This study categorized the car design development process, "four stages", "three competition styles" and "three design decision methods".

Key words: Design Development Process, Car Design Development, Design Decision Methods

1. Introduction

Today, the car companies in Japan are organized to respond to their markets on an international scale. Fourteen car companies in Japan are classified into ten groups according to the collaborative relationships they have with each other, and eight of the fourteen companies collaborates with international car companies in terms of technological innovation. An example of the collaborative approach can be found with in the commonality between integrated platform, and how this has influenced economic efficiencies within the group company. These cooperation aims to ensure the competitive superiority in the market place is pre-empted by short development cycle. Generally, it is said that it take four or five year period for a to be developed from planning through to launch. However, the shortening in the development time is important in order to succeed in today's market where value needs of the customer rapidly changes. Therefore, quick development and decision making are important for the car company, and the new car development process is required to respond within two or three year. This is half of present development cycle. This is to say, that the shortening cycle from the planning and design to market will contribute to know these companies respond to market trends with precision. What kind of design process do the companies build in to development cycle? In addition, how need to know to whether present design process does contribute to such period shortening. This paper, as a consequence, aims to clarify the structure of the current design process and the approaches that inform decision-making within it.
2. Investigation of Car Design Development Process

Car design development process from the viewpoint of planning side is explained in six stages as follows; "1) Research & investigation stage", "2) Basic requirement specification stage", "3) Concepts design stage", "4) Configuration stage", "5) Modeling stage" and "6) Design freeze stage" (Nonaka[1], Abe 2000[2]).

1) Research & investigation stage.
Collect the information which useful for the target of the development car.
Investigate the new design trend and new technology, and apply this information to design.

2) Basic requirement specification stage.
Decided basic requirement specification by planning and layout design department; body class, number of passengers, engine size and etc.

3) Concepts design stage.
Create design concept by using of market report, technology trend, design trend and etc.
Drawing rough sketch and select the design concept.

4) Configuration stage.
Decide configuration cooperate with layout design department.

5) Modeling stage.
Drawing final sketch and decide the design proposed.
Create three dimensional scale model and full size clay model.

6) Design freeze stage.

Freeze the design by mutual consent with an executive, planning department, sales department and other cooperated department.

From "1) Research & investigation stage" to "4) Configuration stage" are divided into 4 stages, but form design stage has just one "5) Molding stage". The work volume at each stage are not similar, therefore it is not suitable to show recent car design development processes. In this study, the car design development process was clarified, through an investigation for car company's design department. The investigation involved 11 companies that develop passenger cars and each have a dedicated design department, from all 14 companies divided into 10 groups in Japan. The investigation was carried out by direct interviews with the heads of design department in each company. The investigation content was divided into three groups, such as 1) organization that is related to the car design development, 2) car design development process and 3) design decision making methods. Each of detailed content is shown in Table 1.

3. Design Development Process of Each Company

At the beginning, design process which could apply to all companies was decided from the finding of the interview. Design process can be divided into four stages, "Advance Stage", "Concept Stage", "Main Stage" and "Tuning Stage". The car's design direction was developed presupposing competition style, and it was clarified by using these four stages in order to each car difference of a purpose and role

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Note: The table content is abstracted and formatted for readability, and may not reflect the exact content of the original document.
competitively. Four stages are explained below;

"Advance Stage": The advanced development of the new car is carried out in this stage according to the information about trends and new technology from the planning and technology department. Two different types of design businesses were existed, one is contract business from planning department, and the other is autonomous business in design department. The design department creates the direction of the new car design at this stage through planning new concepts, drawing sketches and examining the form through scale models.

"Concept Stage": Basic specification and configuration were decided at the first half of this stage, by cooperated with planning and technology department. At the end of this stage, several designs are selected from the lots of proposed design ideas visualized through sketches and scale models (Sugiyama [3]).

"Main Stage": Design was examined at full size model. In this stage, most of the concept's mechanical engineering requirements were cleared and solved. The design department presents final ideas to executives and all divisions that are related new car development.

"Tuning Stage": The final idea that was selected in Main Stage was tuned in this stage. It has to clear the safety standards and adjust to the rigors of mass production without compromising the design idea. Finally, the design was frozen at the conclusion of this stage.

It is proven that the design work at the "Advance Stage" and the "Concept Stage" are similar but the role of the design output from both are quite different, consequently, the initial stage design process is quite different from the presenting six stages at this point. "Advance Stage" is the first development stage, which the design department entrusted to the planning department. On the other hand, planning department mainly controls "Concept Stage", and design department presents the several ideas within a limited area. This to say, these two stages are different that the design department leads the stage or not. "Main Stage" and "Tuning Stage" are dividing modeling stage in to two stages, and these stages are exist in all 11 companies. Moreover, design freeze stage is not a stage but a final process of the "Tuning Stage" in this four design stages. It means that design decision in the "Advance Stage" and "Concept Stage" are more important than the last decision in today's car design development (Sugiyama [4]). The process of each company is explained using four stages in the following.

1) Company A

The advanced section in design department carries out the design study which the planning department requested. The period is different by the project, from the several months to the three or four years. The advanced design ideas shift to Concepts Stage, after they are proposed and are selected in the meeting. In company A, the design competition is always carried out in "Advance Stage", "Concept Stage" and "Main Stage". Company A carries out design competition among the design department at head office, domestic branch, overseas branch, and the design department in group companies. The competitor was selected with consideration for the type of project. Each competitor designs freely to showcase its unique ideas against the design competition. By always carrying out the design competition among the design branches effect to keep their activities and a strain of fresh ideas in the design department. The design directions are always decided in the project meeting through the use of evaluate data, produced by design by the in-house panelist. It is finally decided by company president in consultation combined with the end of the "Main Stage" using the opinion of sales and planning department and evaluated data by the in-house panelist.

2) Company B

Design department is located in the planning department, and it has been organized around the several car-size groups and the strategic group section that is controlled by chief of the headquarters directly. In company B, planning department and planning group in the design department plan the concept, and the project starts with this concept. Advance group within the strategic group is in charge of the advance stage for about 6 months. The advance design work continues through the "Concept Stage" for constraint of this advance stage period. The head of the design department has strong authority, and he can organize the project team from within design departments domestically and internationally. Furthermore, each project leader can freely manage the team. Four ideas remained at the "Concept Stage", and the ideas were narrowed down to one at the "Main Stage". These ideas were proposed by competition style, but whole teams approached it with one objective. Design department reports to the executive in charge of the design department in order to carry out the design decisions at the "Advanced Stage". However, the executive evaluates design ideas from the "Concepts Stage", and the president evaluates depending on circumstances. The executive class decides the design from the early stage in company B.

3) Company C
The design department of company C starts the design after receiving development instruction from the planning department. Design development in "Advanced Stage" does not continue to next stage, therefore "Advanced Stage" is just studying the design. Accordingly, the project starts from the "Concept Stage", and many ideas are discussed at this stage. Company C uses unique competition style in each stages. In "Advanced Stage", design department competes within external design consultant to confirm present design standards and trends. After "Concept Stage", the competition held within the department and international branches. The head of department selects at the design ideas at the "Concept Stage", "Main stage" and "Tuning Stage". These are approved at executive design meetings that hold as clinic. Basically, the design ideas, which do not clear the clinic, can’t go to the next stages. Moreover, design freeze was decided by the executive management meeting with sales and planning department are also heavily dependent on the results of clinic.

4) Company D
The design department of the company D starts the design after receiving a long term development plan from the planning and strategy department. Advance group is in charge of the advance stage for a few months, and present several scale model in the end of the "Advance Stage". From the "Concept Stage", design ideas are evaluated by full size model in the product design groups. "Main Stage" can be divided into sub-stages, one is design approach stage, and the other is detail design stage. In case of design for limited market, the design branch that is familiar with that area designs exclusively. The competition is chosen by the specification of project, and competition held in all stages. For example, it is held at "Advanced Stage" to develop the design ideas, and an external design consultant supplies the design ideas in "Tuning Stage".

Head of design department has been entitled with making design decisions through the whole stages, and all of design issues are transferred to design department. Consequently, design decision meeting is more frequent than other company.

5) Company E
Company E only manufactures small class car to the market. The design department is located in the technology headquarters, and they are organized planning and each mechanical design department. Advance design started in the "Concept Stage" in this company, and these design ideas turn to the concept work immediately. All of the designers create CAD data by themselves, and this data is transferred and evaluated by mechanical design department at the same time. In this company, the design competition is not carried out by all stages; all design ideas are discussed and developed with modification. Sometimes, overflow design work is briefed to an external design consultant, the role of the external design consultant is not competitor but design partner in this company.

Head of the design department controls and makes the decision about design ideas at the "Concept Stage". Then, in "Main Stage" and "Tuning Stage", design proposed from design department and gets an agreement by business meetings held, at which all executives are presented.

6) Company F
Company F has the flexible design organization. Each project can comparatively freely select the designer as a necessity. The rotation is done every month in the department, and it is done every half year of the outside department. The rotation of the designer is always done for the project. The project team is formed by the member who was selected from each department at the beginning of the new car project starts. At this time, only design planning group are joined this project team in behalf of the design department. Afterwards, the design planning group starts the design with the rough layout plans and design concept. When the design work shift from the design planning group to the studio group, the design planning group member remains in the studio group in the first period, and the design work is smoothly handed over by this flexible organization system. All of the project is checked by the executives in "Concept and Main Stage", and it is also approved by management meeting in "Tuning Stage". Incidentally, company F is group company of A; therefore the contract project from A follows the design development process of company A.

7) Company G
Company G is a perfectly subsidiary in company A; therefore the design development process is completely equal to company A. Moreover, company G is one of competitors in company A’s design competitive approaches that was above mentioned. Company G have to carry out the "Tuning Stage" notwithstanding the results of the design competition in case of the production in company G has been decided. These design development process were consistently permeated into the all subsidiary companies. However, the difference in design proposal from the company A is the main task in company G in these days. Therefore, G’s design department manages proposals of
new packages and body frames design from the designers.
8) Company H
Company H is a subsidiary in company B, therefore the
design development process is almost equal to company
B. Ordinarily, the new project is carried out by project
leader comes from company B. Company H doesn't have
a design competition in spite of a subsidiary in company
B, because the type of the cars in company H is limited
commercial vehicles. Design proposals by the competition
is not suitable for the commercial vehicles, and it seems
to be efficient that the project leader of B manage H's
designers. Design decision in design process is the equal
with company B.
9) Company I
Company I doesn't have an advanced group, all of the
designers carry out the research and planning work
and create new package ideas with studio engineers.
 Afterwards, several scale model are made and are evaluated
at the "Concepts Stage". In "Concepts Stage", sometimes
the clinic by the outside specialist is carried out in order
to find the identity of I. In the "Main Stage", the 2 or 3
different styling plans are presented by full size model
that was constructed by same package. The selected
plan was tuned for the production in "Tuning Stage", but
technical requirement is strict at this stage. Because, I is
the technology oriented company, and unique technology
change into the unique product. Design Department uses
the overseas branch only for the research and concept
making. It also uses external design consultants as a
stimulation for its in-house designers. Company I uses
the externals only for in the first half stage, because the
technical requirement is so strict at the latter stage.
New project starts by the plan taken by design department
from "Concept Stage", and design ideas were decided by
the negotiation between head of design department and
project supervisor. Afterwards, it is decided by president
that the design proposed by design department in "Main &
Tuning Stage".
10) Company J
Project manager plans the new project and start the design
work. At this time, the idea is selected for the new project
from the stock of each designer’s ideas, because it has no
advance group in company J. All of the designers in J unite
in designing and join the same project. J uses the external
design consultants only for stimulation of the in-house
designers.
 Decision-making was transferred to design department at
all of the stages. But, it is necessary to get an agreement
from the board that was organized by president and higher
management class in the end of the "Concept Stage".
Design department were direct controlled by the executive
managing director who understands design activities in
detail, therefore design department can manage without any
restraints.
11) Company K
When the new project start, designer participates research
work and makes new concepts for new projects, and an
external design consultant was used in case there is a
necessity for market research and concept making. Next,
package group in design department create new package
and decides the character for new car body in "Advance
Stage". Afterwards, the design ideas are discussed and
examined in each stage. The design competition is carried
in company K and the design competition is dependent on
the project leader. For example, they uses overseas branches
in the new project aims to provide for the worldwide area,
ask for the external consultants just to create new design to
stimulate in-house design and etc. there is no limit to the
number of ideas proposed from each branch and design
groups, and project leader manages each project freely.
Design ideas are decided by the executive manager
in charge in "Advance, Concept and Main Stages".
Accordingly, the final design is approved by the president
at the decision meetings organized by the planning, sales,
production, and cost accounting executives.
The features of eleven companies are summarized the
above mentioned.

4. The "Design Stage" and Design Process.
4.1. Relationship between "Design Stages" in Eleven
Companies
The relation of these four stages is quite different by each
company (Figure 1). Above all, it is the most different point
that the role of the "Advanced Stage".
In company A, G and K, "Advanced Stage" is the
most important stages in the design process. All of the
advanced work in "Advanced Stage" is connected with the
commercial product; it is not finished only for the study
work and future proposal work. The common point of three
companies is; there is no time restriction on "Advance
Stage" and the design proposal are repeated until the
good design ideas are resolved. "Advance Stage" is the
indispensable stage for these three companies.
Secondly, company B, C, D, E and H has "Advanced
Stage", but the design work in this stage is not necessarily
connected to the commercial product. Sometimes,
 voluntary design works are held in this stage. Thirdly, company F, I and J have no advanced group in design department, and the "Advanced Stage" does not exist in the design process. Conversely, ability to produce specific car types has been limited by the size of these three companies, and designer can concentrate these limited fields to create new ideas without having to place the "Advanced Stage" within the design process.

4.2. Design Competition in Four Stages

Car design development is fundamentally carried out by competition style. In this paper, eleven companies can be divided into three groups by the type of competition (Figure 2).

1) Compete in all stages.
This type is company B, C, D and H. Company B, C and H carried out the competition intentionally in all stages, but company D carried out the competition at the "Tuning Stage" in case of an idea is not selected at the "Main Stage". Therefore, the reasons for the competition are different from B, C, H and D. Moreover, the role of the external design consultant in competition is different from B, H and C. B and H are taking the external design consultant to competition. But, company C only asks to design for the external design consultants, and the results are only used for verification of the design trend and stimulation for in-house designer never reflected to the project.

2) Competition at the "Advance, Concept and Main Stages".
This type is company A, G and K. These companies are same at the "Advanced Stage" which is the most important stages in the design process. That is to say, lots of ideas are evaluated at the "Advanced Stage" and the design ideas are clearly fixed at the end of the "Main Stage", therefore the "Tuning Stage" can concentrate on the detail tuning without competition from these companies.

3) Competition at the "Concept Stages".
This type is company E, F, I and J. The producing car type has been limited in these four companies and these four companies are short of designers to do the competition after "Main Stage".

4.3. Design Decision in Four Stages

The design decision is held at each stage. Rightfully, the requirement that enable design decision is getting seriously stage-by-stage, and design decision methods are classified into three groups (Figure 3).

1) Consulted by Project Team.
This system applies to company A, C and G. A and G are

Figure 1. Relationship between "Design Stages" in Eleven
doing same decision method, because G is a subsidiary in A. It is a point in common to three companies that the design is decided by using of the evaluation data that project collected and analyzed. In A and G, the design evaluation were carried out by the in-house employee. Conversely, the design evaluation were carried out by outside in C. The design decision is decided in the council system, and the evaluation data is identified the important factor in this council system. Design evaluation and decision system have been established and used in these three companies.

2) Decision by the Key Person.
This system applies to company B, D, H, I and K. Decision by the key person is the method in which the body that chaired by the key person decides the design. This system is divided into two groups, one group has key person who is always a president, and the other group has the key person who changes to the higher position with the stage approaching the latter; such as head of department, executive in charge and president. All companies have made the key person of the "Tuning Stage" to be a president. It means that the president needs to have the responsibility for the final decision. However, the president does not reject the design by himself, it is smoothly decided by prior adjustment and negotiation.

3) Entrusting to the Design Department.
This system applies to company E, F and J. Head of design department decides the design and executive or president approve it. The decisiveness were authorized and transferred to design department. The size of three companies is not so huge and the daily communication between design department and other departments is well, therefore it trust that the decision by the design department is credible.

5. Conclusion
This study clarified the car design development process through the comparison of eleven Japanese car company's design development processes. Consequently, the design development process can be divided into four stages, such as "Advance Stage", "Concept Stage", "Main Stage" and "Tuning Stage". The role of the each stage was clarified through the relationship between four stages. Secondly, it was identified that most of the companies have design competitions within the design development process, and the role of the design competition within the design branches and external design consultants were clarified into three groups. Moreover, it was clarified that the design decision method can divide into three groups, such as, "Consulted by the Project Team", "Decision by the Key

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Figure 2. Design Competition in Four Stages
Person", and "Entrusting to the Design Department".

This study clarified the car design development process the above mentioned. "Four stages", "Three competition styles" and "Three design decision methods" were clarified from this study.

However, these results can not be perfect in its evolution of car design, as the design development process always changes. The complicated problems except for the design process also exists. The three viewpoints identified in this study are useful and beneficial for adaptation to the social environment that design development and organization will be in the future. These seem to be able to become an index for predicting how car design development can be designed and developed. This study showed an index.

References