

**MANAGING NOVELTY AT THE INTERFACES BETWEEN CONCEPT AND
PRODUCT: CASE STUDIES FROM THE AUTOMOTIVE INDUSTRY**

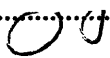
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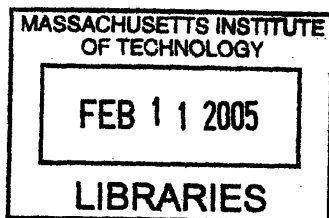
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Abstract

Appearance of the product is a discerning factor for the consumers purchase decisions. Time from concept to product creation is a critical factor in the competitive automotive industry. The period to develop a product is dependant on the people, content and the technology changes that constitute a large majority of expense allocation, and time invested. The greater the degree of change from something established and successful, the more difficult it becomes to incorporate the change into a product. Being successive in the automotive industry relies on the ability to maintain market presence with new and innovative products, while shortening the cycle time associated with new product design, development, and its introduction. Increasing capability to manage changes becomes more challenging as product complexity and customer demands increase and product life cycles decrease.

How automotive manufacturers manage these changes during the critical product definition phase through process, tools and methods is the central discussion of this paper. The intent of this thesis is to identify the processes and key enablers that allow a rapid development process for appearance related systems, in particular the interior environment of the vehicle. Five cases that effect the interior trim environment will be reviewed to understand the methods, which allow the migration of novelty. Situations that will be studied will be introductions to aspects of: new technology, strategies, and the impact of late additions.

To compare and contrast the degree of change occurring in these cases, a framework is essential to identify novelty. The ability and skills which an organization can perform changes is defined as organizational capability. This term describes how people within the organization manage to perform work. Specific case studies will be analyzed –reviewing the novelty introduced to the program, the organizational capability utilized, and the artifacts and processes employed to develop a final product within the division of the Sport Utility Vehicle Body on Frame, of Ford Motor Company, and contrasting comparisons to similar areas within Nissan Corporation, and Toyota Motor Corporation. Through these cases different types of novelty are revealed and its impact upon the interior trim system.

It is argued that allotting more time in the preparation and early planning stages will reconcile problems that may arise later on. The approaches that these departments use: formal, informal meetings, conference calls, and written communication to manage novelty will be reviewed and compared in order to provide recommendations for improvement.

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This has been an arduous journey. I have been fortunate to gain a different perspective through my coursework, and in the process gained many friends. Like the Robert Frost, poem I took the road less traveled –however I have been enriched by the experience and blessed with new friends.

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Lastly it has been commented by many (but mostly by my husband) that I have transformed frequently into the alter ego of Stella, the moody virago. I dedicate this thesis to my husband, Daniel Orest Dymtro Zarewych –this is corny but you were the 'wind beneath my wings' and the light at the end of the long, dark tunnel. Thank you for the sacrifices you made and still being there in the end.

TABLE OF CONTENTS

Managing Novelty at the Interfaces Between Concept and Product: Case Studies From the Automotive Industry	1
Acknowledgements.....	4
Table of Contents	5
List of Tables	8
Table 1 –Is, Is Not.....	8
Table 2 -Error Proofing.....	8
Table 3 –Case 2 Types of Cross-Functional Meetings	8
Table 4 –Case 3 Types of Cross-Functional Meetings	8
Table 5 –Case 5 Types of Cross-Functional Meetings	8
Table 6 –Summary of All Cases	8
List of Figures	9
Figure 1 - Familiarity Matrix	9
Figure 2 - 3-T Framework for Managing Knowledge across Boundaries	9
Figure 3 – Hierarchy of Novelty	9
Figure 4 - Relation of Different Participants Involved for OEM's 1 and 2	9
Figure 5 - Relation of Different Participants Involved for OEM 3.....	9
Figure 6 – Illustration and Location of Parts Associated with the Satellite Dish Radio Antenna System	9
Figure 7 – Illustration and Location of 2002 Jeep Cherokee Parts Associated with the Safety Canopy System	9
Figure 8 – Illustration of the Overhead Console System.....	9
Figure 9 – Illustration and Location of Parts with Tweeter Design.....	9
Figure 10 – Familiarity Matrix for Case 1	9
Figure 11 – Familiarity Matrix for Case 2	9
Figure 12 – Familiarity Matrix for Case 3	9
Figure 13 – Familiarity Matrix for Case 4	9
Figure 14 – Familiarity Matrix for Case 5	9
Figure 15 – Triage Assessment for All Cases.....	9
Figure 16 – Familiarity Matrix for All Cases	9
1.0 Introduction.....	10
1.1 Background.....	10
1.2 Objectives	11
2.0 Literature Review.....	13
2.1 Definitions.....	13
2.1.1 System.....	13
2.1.2 Complexity.....	13
2.1.3 Information	13
2.1.4 Knowledge	13
2.1.5 Participant	13
2.1.6 Actor	13
2.1.7 Infrastructure.....	13
2.1.8 Capacity	14
2.1.9 Ability	14

2.1.10	Dependence.....	14
2.1.11	Difference	14
2.1.12	Novelty.....	14
2.1.13	Boundary.....	14
2.1.14	Artifact, Object	14
2.1.15	Organizational Capability	14
2.2	Types of Organization Structures	15
2.2.1	Functional Organization.....	15
2.2.2	Project Organization	16
2.2.3	Matrix Organization.....	16
2.3	Relevant Research.....	16
2.3.1	Familiarity Matrix	16
2.3.2	Knowledge-Driven Work.....	18
2.3.3	3 T Framework.....	18
2.3.4	Hierarchy of Novelty	20
2.3.5	Adaptive Learning	21
2.3.6	Corporate Strategy	21
2.3.7	Core Rigidities	22
2.4	Summary –Where This All Fits In.....	22
3.0	Setting	24
4.0	Methods.....	26
4.1	Motivation –Theoretical Questions.....	26
4.2	Approach.....	26
4.3	Company Selection	28
4.4	Case Introduction	28
4.4.1	The First Case – "Late Addition –Satellite Dish Radio Antenna System"	29
4.4.2	The Second Case –"Safety Canopy System Technology Impacts"	30
4.4.3	The Third Case – "Corporate Strategy –Overhead Consoles"	31
4.4.4	The Fourth Case – "Rear Glass and Sheet Metal –Late Change"	32
4.4.5	The Fifth Case – "Tweeter Design"	32
5.0	Case Studies	34
5.1	The First Case – "Late Addition –Satellite Dish Radio Antenna System"	34
5.1.1	Background: What is a Satellite Dish Radio Antenna System?	34
5.1.2	Novelty Encountered in the Satellite Radio System	34
5.1.3	Relationship with Other Systems.....	35
5.1.4	Objects/Artifacts	36
5.1.5	Ends/Results.....	36
5.2	The Second Case "Safety Canopy System Technology Impacts"	36
5.2.1	Background: What is the Safety Canopy System?	36
5.2.2	Novelty Encountered in the Air Curtain System	37
5.2.3	Relationship with Other Systems.....	38
5.2.4	Objects and Artifacts.....	38
5.2.5	Ends/Results.....	39
5.3	The Third Case – "Corporate Strategy – Overhead Consoles"	39
5.3.1	Background: What is the Overhead Console?	39
5.3.2	Novelty Encountered in the Corporate Overhead Console System	40

5.3.3	Relationship with Other Systems.....	40
5.3.4	Objects and Artifacts.....	41
5.3.5	Ends/Results.....	42
5.4	The Fourth Case – "Rear Glass and Sheet Metal –Late Change for the Upper C-Pillar Hard Trim"	42
5.4.1	Background: What is the Upper C-Pillar Hard Trim?	42
5.4.2	Novelty Encountered in the Upper C-Pillar Trim.....	42
5.4.3	Relationship with Other Systems.....	43
5.4.4	Objects/Artifacts	44
5.4.5	Ends/Results.....	45
5.5	The Fifth Case – "Tweeter Design"	45
5.5.1	Background: What is the Tweeter?.....	45
5.5.2	Novelty Encountered in the Upper C-Pillar Trim.....	46
5.5.3	Relationship with Other Systems.....	46
5.5.4	Objects/Artifacts	47
5.5.5	Ends/Results.....	48
6.0	Discussion	49
6.1	Satellite Dish Radio Antenna System	49
6.1.1	Technological Familiarity Matrix	49
6.1.2	Objects/Artifacts	49
6.1.3	Management of Novelty –Dynamics	50
6.2	Safety Canopy System	52
6.2.1	Technological Familiarity Matrix	52
6.2.2	Objects/Artifacts	52
6.2.3	Management of Novelty - Dynamics	55
6.3	Overhead Consoles Strategy	57
6.3.1	Technological Familiarity Matrix	57
6.3.2	Objects/Artifacts	58
6.3.3	Management of Novelty - Dynamics	59
6.4	Upper C-Pillar Hard Trim.....	61
6.4.1	Technological Familiarity Matrix	61
6.4.2	Objects/Artifacts	62
6.4.3	Management of Novelty – Dynamics	63
6.5	Tweeter Design	65
6.5.1	Technological Familiarity Matrix	65
6.5.2	Objects/Artifacts	66
6.5.3	Management of Novelty – Dynamics	67
7.0	Observations	70
7.1	General Observations.....	70
7.2	Case Observations.....	72
7.3	Proposed Triage	74
8.0	Conclusions and Recommendations	77
8.1	Technological Familiarity Matrix	77
8.2	Objects/Artifacts	78
8.3	Management of Novelty – Dynamics	79
8.4	Conclusions.....	81

8.5	Recommendations.....	81
9.0	Future Work.....	84
10.0	References.....	86
	Appendices.....	89

LIST OF TABLES

Table 1 –Is, Is Not

Table 2 -Error Proofing

Table 3 –Case 2 Types of Cross-Functional Meetings

Table 4 –Case 3 Types of Cross-Functional Meetings

Table 5 –Case 5 Types of Cross-Functional Meetings

Table 6 –Summary of All Cases

LIST OF FIGURES

Figure 1 - Familiarity Matrix

Figure 2 - 3-T Framework for Managing Knowledge across Boundaries

Figure 3 – Hierarchy of Novelty

Figure 4 - Relation of Different Participants Involved for OEM's 1 and 2

Figure 5 - Relation of Different Participants Involved for OEM 3

Figure 6 – Illustration and Location of Parts Associated with the Satellite Dish Radio Antenna System

Figure 7 – Illustration and Location of 2002 Jeep Cherokee Parts Associated with the Safety Canopy System

Figure 8 – Illustration of the Overhead Console System

Figure 9 – Illustration and Location of Parts with Tweeter Design

Figure 10 – Familiarity Matrix for Case 1

Figure 11 – Familiarity Matrix for Case 2

Figure 12 – Familiarity Matrix for Case 3

Figure 13 – Familiarity Matrix for Case 4

Figure 14 – Familiarity Matrix for Case 5

Figure 15 – Triage Assessment for All Cases

Figure 16 – Familiarity Matrix for All Cases

1.0 INTRODUCTION

1.1 Background

There is increasing pressure for automotive manufacturers to shorten the 'time to market' their products, while still improving quality and reducing expenses. To meet cost objectives and customer requirements, successful product development requires the participation, skills and knowledge of multiple disciplines including finance, marketing, manufacturing, engineering, and studio styling.

The vehicle styling, and appearance of the product becomes a critical decision factor for consumers. The focus of this thesis involves case studies, which illustrate the interactions of participants who design interior trim systems. The existing system for designing and styling interior trim appearance parts is based on a generic vehicle development process that is dependent on the amount of change occurring on the vehicle platform. Generally the product development process begins with the following stages: the idea, the definition/feasibility, development/integration, tooling/processes and launch. During the idea stage, the selection of the supplier for a commodity occurs, followed by the definition/feasibility stage when events proceed to program assumptions and negotiation, thereafter agreement on costs for produced commodities are finalized. Next, the development/integration stage begins which involves the following tasks: feasibility assessment of part performance to requirements and development of aesthetically pleasing parts. Once this stage has passed, the tooling/processes phase begins (a period when tools are kicked off) and lastly, the launch stage (the production of parts) commences.

While all of these phases require cross-functional interactions, the aforementioned three stages (definition/feasibility, development/integration, and tooling/processes) of this process require an upfront communication between product engineering, design/styling and internal groups. Internal groups with product engineering (electrical, interior trim, exterior trim, climate control) are all required to coordinate to develop a vehicle. However, the real-estate (package space) required for each part, and the functionality required to pass system requirements presents a tradeoff with interfacing systems. Additionally, once the real-estate and part functionality is reconciled with the interfacing systems, the quest for the (perfect) appearance and esthetic appeal for the part begins. This quest is lengthy and creates many design changes that impact the interfacing systems.

For example, when designing a headliner system, it is important to understand pertinent sheet metal attachment points and whether changes occur in the location and/or the material dimensions (thickness). More specifically just this parameter if changed, impacts the headliner attachment scheme (how and when it attaches), and the attachment methods (may require new clips, screws). Further including the remainder of the systems behind the headliner (climate control, coat hook brackets, wiring, moon roof cassettes) and the systems attaching on top of it (hard trim, coat hooks, visors, overhead consoles) increases the difficulty of the problem. The situation becomes more complex based on the number of changes impacting each respective part. Suppose the headliner design is 'settled'. This design eventually becomes modified in order to improve the appearance of the part. Radius changes of cutouts, and how the headliner surface

sweeps and blends into different angles to interface with other mating parts is revised repeatedly until the styling group is satisfied with the headliner surface design. Changes are rarely superficial, and require package space displacement of the headliner system (and the respective components attached on, and located behind the system) that impact functionality and manufacturing feasibility of this system. Hence, this interplay of communication is extremely important because within these phases the development of the product, its functionality, theme, material utilization, manufacture, and assembly are all defined.

Historically, the late completion of these steps can jeopardize a program in meeting its timing delivery. Delays resulting in this part of the process are not offset downstream in the program's timing. These upfront delays can contribute and/or result in manufacturing problems and delayed production dates. Increased pressure to reduce 'time to market' requires effective management and sharing of knowledge among the interfacing systems (boundaries). As reflected in the example above, there are many dependencies for a specific system, e.g. the headliner system are still fluid and require coordination to develop an accepted design. If an accepted design is not established, many parts within the headliner system will not be ready to be tooled for production. Knowledge is thus, recognized as a vital source of competitive advantage and the criticality becomes the company's ability to deal efficiently with its own knowledge to generate value and enrichment of its organization.

1.2 Objectives

This thesis will focus on the interior trim environment of the vehicle. Through presented cases, different types of novelty will be reviewed to gain understanding of its subsequent impact to the interior trim system. Novelty is the challenge that arises when operatives change between a person's boundaries (or system's) to other interfaces. Novelty could result from a different interfacing supplier introduced to the program, changing content features, implementation of corporate strategies, or new organizational personnel and/or processes. The cases studied include the consequence of: new technology, strategies, and late additions and the approaches used to incorporate them into a product, of knowledge management. This work will review case studies and attempt to reconcile how individuals establish a common ground to resolve problems. The study will explore the challenges of cross-functional interactions (boundary activities) for interior trim components of the headliner, the overhead console, and the hard trim.

The dynamics of team structure and process will be studied for each of the cases, along with the systemic process of creating, acquiring, disseminating, leveraging and using the obtained knowledge. Attention will be placed on the activities used as a boundary, type of boundary, frequency and period of the activities, the ability of the participants involved to represent their knowledge (to evolve the product), the identification of actors (the people that achieve the change) and the resolution of the problems.

By using the Familiarity Matrix (Roberts and Berry, 1985), the novelty presented in these cases and the company's technological capability to envelope them into products with respect to the company's base market segment will be tabled. The matrix will be used in this paper to understand the impact of novelty on a company and how this novelty aligns to company's consumer market.

The Hierarchy of Novelty and the 3-T Framework will be applied to these cases to identify the type of knowledge boundary presented, the level of novelty, the amount of difference, dependency and novelty faced at each boundaries and type of processes (capability) and artifacts employed.

The approaches that these areas employ to manage the novelty will be reviewed and compared in order to provide recommendations for improvement.

This paper is divided into eight sections. Chapter 1, sets the objectives; Chapter 2, clarifies definitions and explains central key concepts; Chapter 3 and 4 supplies the setting and methodology; Chapter 5 and 6 presents the framework and discussion of the cases; and Chapter 7, offers generic observations of the case studies and a presents a proposed triage method; Chapter 8 provides conclusions and recommendations; and Chapter 9 closes by exploring future work in this area.

2.0 LITERATURE REVIEW

The section provides a gamut of definitions, ideas and concepts important for this document, and is articulated into three parts. The first part, defines terminology used throughout this paper. In the second portion, main ideas and concepts from various disciplines are summarized, and the last part relates how all these concepts support knowledge management.

2.1 Definitions

The key words listed below, will be referenced frequently in this document. A brief explanation on their meaning is required for clarification.

2.1.1 System

"A system is a perceived whole whose elements 'hang together' because they continually affect each other over time and operate toward a common purpose" (www.solonline.org). This word has its origins from the Greek verb, which meant, "to cause to stand together".

Another definition, defines the word system as "a collection of things or elements which, working together, produce a result not achievable by things alone" (Maier, Rechten, 2002).

2.1.2 Complexity

Complexity measures the number of interrelationships among system levels, and sub-elements. In other words, "having many interrelated elements and interfaces (Crawley, 2003)

2.1.3 Information

Information is defined as something that provides a new perspective for interpreting events, or objects, it discloses unseen meanings and provides enlightenment on unexpected connections. Information becomes the medium to elicit and create knowledge (the flow of messages, whereas knowledge becomes created by information).

2.1.4 Knowledge

Knowledge throughout this text is defined as a 'dynamic human process of justifying personal belief toward the truth'. Knowledge is about action, and is grounded in beliefs, commitments, and depends on perspectives, and meanings (context-specific and relational).

2.1.5 Participant

This word means "someone taking part in an activity" (WordNet 2.0, WordIQ.com, 2004). This word is specifically used instead of the word, actor.

2.1.6 Actor

An actor implies a person who acts on the information to get things done.

2.1.7 Infrastructure

Characterizes the features of a system or organization without the participants. This is the core precept of an organization that provides the means for performing an assignment. This includes process methods, reporting structure and accountability, roles and responsibilities, and objectives. The infrastructure established is temporal, yet defines the capability of a system (e.g.

a text paging system is an infrastructure that has a defined method for intra-company communication nationwide).

2.1.8 Capacity

The capacity is "the power of receiving and holding ideas, knowledge; the receptive faculty; capability of understanding or feeling" (Webster Revised Unabridged, WordIQ.com, 2004). Capacity is the potential of the infrastructure to allow work to be performed (e.g. a text paging system is an infrastructure that allows intra-company email communication).

2.1.9 Ability

The ability of a participant is the power to perform a skill or competency in doing an activity. This definition is further extended to mean the participants utilization of the existing infrastructure, tools, objects and knowledge.

2.1.10 Dependence

"It is the state of being influenced or determined by or subject to another" (Merriam-Webster, 2003). This implies that there are differences in the abilities of the participants of the system that create dependence.

2.1.11 Difference

Difference in this context pertains to the situation when the level of knowledge known by the interacting parties is unequal. This difference can be the result due to the specialization in a specific area causes the party to be oblivious to any changes outside of that specialty.

2.1.12 Novelty

Novelty is the "psychological quality of being new" (WordNet 2.0, WordIQ.com, 2004). It is the subjective perception of the person that creates the novelty to an object, a situation, and an environment. Novelty in the context of this work, is a change that is an exposure, something unique, different that has not been encountered when compared to the mode of operitis.

2.1.13 Boundary

Physical, and/or mental barriers created by novelty resulting from the different capacities of the participants. Boundaries can also be defined as difference and dependence (Carlile, 2004). By this context, the introduction of novelty creates influences (dependence) and/or a difference in the level of knowledge understood. Thus it becomes increasingly important to distinguish the known versus the unknown knowledge in order to understand the boundary.

2.1.14 Artifact, Object

Accepted by the participants, it is the 'means' that knowledge is understood, and communicated the needs and differences of the participants. An artifact can have multiple meanings to various participants. These multiple meanings can create different interpretations. Artifacts can be, objects, and language.

2.1.15 Organizational Capability

Capability represents the potential of a system to achieve its directive. Organizational capability relies on the abilities of the actors, and the system capacity.

Another way of representing this idea is by using the mathematical equation presented by Gilbert. Restricted to positive integers, the capability is defined as:

$$X_{(\text{System})} = X (I)^m * \text{alpha} (A)^n$$

The $X_{(\text{system})}$ is the Capability of the system equal to the Capacity of the infrastructure (X), or if more $(I)^m$ multiplied by the Ability (alpha) of the actors, or if more $(A)^n$ that are accessing the capacity.

If (X) and (alpha) can equal values between 0 – 1, then $X_{(\text{system})}$ can equal 0 to positive numbers. Using the text pager examples used previously in the definitions, if there are two actors that are capable, thus $\text{alpha} = 1$, and $(A)^n = 1^{n=2}$. The capacity of the text paging infrastructure exists, and readily understood with instruction, thus $X = 0.70$, and there is only one infrastructure in this example, so $(I)^m = 1^{n=1}$

Thus, the Capability of the system, $X_{(\text{system})}$ is equal to: 0.80 (the numbers for alpha , and X were arbitrarily picked to show that mathematical equation is feasible to illustrate this idea).

This definition is important since it provides understanding when an object can be used as a boundary.

2.2 Types of Organization Structures

Communication patterns can be better understood if the organizational structure is defined and explained. The goal of any organization is to function effectively. This is achieved by the organization: creating reporting relationships, providing information and alternatives to perform tasks. Any type of organization primarily focuses on one of the two value streams: technology or the market. A correlation study has shown some validation that depending on the state of the technology (stable versus dynamic) specific organizational structures is more suited to these situations (Marquis and Straight, 1965). The information below provides some clarification in understanding the different types of organizational structures.

2.2.1 Functional Organization

This type of organization had its origins since the 12th century from universities that grouped departments in specialized areas of knowledge. It is characterized by having the employment of a large number of highly educated, specialized employees. Primarily found in engineering, and research and development, other organizations create the same type of organization, when hiring highly educated people leading to greater specialization.

Having the employees grouped by responsibility, expertise, and region focusing on tasks or specialties can configure department organizations. The department organization is structured either by: product and function (functional grouping in each product organization) or function and product (product line grouping in each function. The department organization focuses on the technological value stream, and gains a major amount of its organizational capability via contact with other colleague contact (Allen, 1984). This communication, allows the sharing of common intellectual themes and interests. Thus, department organizations have low interdependencies (independent of each other) since the knowledge, and technology development is evolving and dynamic.

However, the department organization tends to be ineffective for stimulation and growth of cross-disciplinary research and collaboration. This can present a dilemma since new product creation requires the integration of knowledge from different specialties. Due to this specialization, 'chimney like' departments and intra-organizational resistance exacerbate incompatibilities in relationships and interfaces between different specialty groups. Coordination between disparate specialties becomes extremely difficult, and leads to generic assumptions of other needs and/or direction that have not been fully established. These assumptions may develop into an unfeasible product.

2.2.2 Project Organization

This organization structure provides better coordination of achieving goals, since specialists from the department organization are removed and relocated, reporting to one person, and develop organization allegiance. This generates a high degree of interdependence, and is ideal for mature technologies. The project organizational form is aligned to the market value stream, and is more agile in coping to changes. It provides a singular, well-defined interface with the market thus providing a perfect conduit for transmission of market information. The dynamic market becomes the stimuli for innovation and new product creation or augmentation (Utterback, 1976).

The specialists on the project teams are beneficial in aligning the application of a specialty to the development of a new product; however this could eventually lead to the specialist obsolescence of knowledge if the area of specialty is dynamically changing. This particular separation of the specialist from their home department organization, and its stimulating culture, leads to less knowledge and information of newer developments. If a company aligns itself to be a project organization structure it leads to the gradual erosion of the organization's technical base and capability.

2.2.3 Matrix Organization

Matrix organization attempts to reconcile the negative aspects of both the department and project organizational structures. The specialists are not removed from their home organization, however these specialists are also aligned to the project team in supporting a new product. This type of organization allows greater interaction of project and department teams thus improving coordination amongst the various specialties, while still allowing the specialties to be independent and maintain development of emerging technologies. However, the complex dual reporting structure generates a high degree of contention between the two teams, particularly the assignment of tasks.

2.3 Relevant Research

The literature mentioned in this section contains central concepts and ideas that the author utilized in order to understand and analyze knowledge management behind the organizations studied in the cases.

2.3.1 Familiarity Matrix

The Familiarity Matrix introduced by Roberts and Berry assesses the appropriateness of various "new business entry" alternatives such as internal development, alliances, joint ventures, equity investments and acquisitions (Roberts and Berry, 1985). The matrix in the context of this paper

is used as one of the fundamental tools for measuring and assessing the level of novelty encountered. Figure 1 shows the Familiarity Matrix.

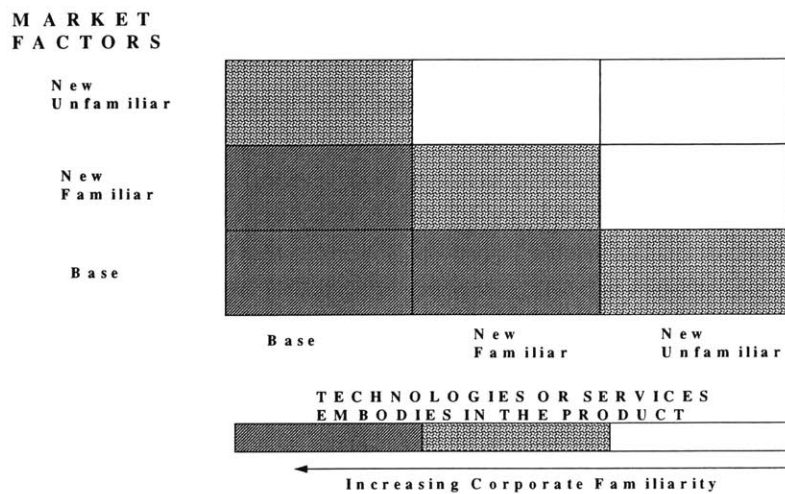


Figure 1 - Familiarity Matrix

The x-axis, measures the technological familiarity of a company with respect to the novelty (Roberts, 2003). The terms are defined as follows:

1. The Base segment defines technology that is currently embodied within existing company products.
2. The New, Familiar can be characterized by:
 - a) The technological capability used within the corporation (e.g. process) but not embodied in existing products.
 - b) New technology relates to or overlaps existing technical skills or knowledge
3. The New, Unfamiliar is the technical skills/knowledge that exists within a corporation but not translated in process.

The y-axis, measures the market familiarity. The market familiarity can be defined to be the company's knowledge and infrastructure specifically supporting to a component or more broadly defined to encompass a company's familiarity to a market compared to competitors (e.g. vehicle audience). If any one of these factors change (the customer segment, functionality, channels of reaching consumer) then the market moves out of a base market segment to new, familiar, or new, unfamiliar segments.

To clarify, the positioning of a company's proposed business development along the two axes of technology and market familiarity is the focus of the matrix. The company's current primary business by definition uses its "base technology" on behalf of its "base market"; other business developments will be positioned in relation to this reference point (being closer or further away).

The Familiarity Matrix can be employed to see how a company's technology, strategy or other business decisions compare to established company products –and provides an indication of how prepared the company is in managing innovation. The matrix will be used as an additional tool in the detection of novelty encountered by an organization.

2.3.2 Knowledge-Driven Work

This work succeeds 'humanware' a term coined by Paul MacDuffie and Harao Shimada to describe that the specifications of the technology employed are inseparable from the skills and knowledge of employees operating the hardware. This led to research on work practices gathered on eight companies based in Japan and the United States (Cutcher-Gershenfeld, et al, 1998). This work is based on the idea that there are no formal work practices. Knowledge is embedded – who does the work, how the knowledge is communicated, and the use of explicit or tacit knowledge in everyday situations. Explicit knowledge is described as being information derived from manuals, books, policies, and drawings, whereas tacit knowledge is shared, problem solving techniques that may utilize mental models (e.g. schemata, paradigms, perspectives, beliefs), symbols, metaphors are unique meanings and/or acronyms not known outside of a specific organization.

Based on the companies researched, knowledge is shared by way of diffusion (piece meal, imposed or negotiated). The premise of the diffusion of work practices is that it is a process by which groups of people create new understandings, adoption of new work practices in the generation and sharing of knowledge. Virtual knowledge is this understanding, based on collective iterations that changes tacit knowledge into explicit knowledge which can be shared. The impact of virtual knowledge is seen in an organization by the way in which groups anticipate and respond to changes. Virtual knowledge is created when employees combine their individual knowledge and shared expertise, to a collective goal and work out a solution. Knowledge generated is dependant on the quality of the inputs given, and the variety of perspectives this provides enrichment in the number of options considered and the applicability of knowledge created. The saying holds true, "the whole is greater than the sum of the parts" –since minor changes can perturb or even destroy the intended product.

Other authors, Nonaka and Takeuchi further discuss the necessity of creating redundancy of knowledge among the workforce. The basis of this need of information is that employees across or within the organization require more knowledge than needed to complete daily activities. The 'overlapping' of information is shared to promote tacit knowledge – and people are able to sense what others attempt to articulate. Redundancy enables people to occupy each other's functional boundaries and solicit advice, provide new information from different perspectives, and create necessary communication channels. This theory provides further understanding with large or small gaps that occur in the "simultaneous meaning of events" (Cutcher-Gershenfeld, et al, 1998). Diverse perspectives, and a variety of meanings are thus, simultaneously generated when an event occurs. Large gaps in meanings that are attributed to an event that requires dialogue to reduce the gap before knowledge generation begins. Similarly small gaps in meanings of occurring events allow the ability to construct new knowledge.

Therefore, this work recognizes that virtual knowledge is a shared event, which requires a level of understanding in order for all participants to reach a collective goal.

2.3.3 3 T Framework

From Carlile's research it is understood that knowledge is difficult to transform ideas in solving problems, particularly across different departments. Knowledge is localized (known specifically to that area/situation), embedded (understood, familiar approaches known for addressing issue)

invested and for many costly expenditures if change is required (or committed, establish best practice for achieving solution). How this knowledge is used to change a situation from a problem to developing a solution depends on the type of boundaries involved. Boundaries can be syntactic (information has clearly established definitions understood by all e.g. Yes/No), semantic (information has different interpretations that are not known by the communicating groups e.g. the hand sign for 'ok' has a different connotation for the Brazilian populace), and pragmatic (intrinsic understanding that changing different parameters in turn, creates different consequences, e.g. compromises). All boundaries therefore, require a 'language' to communicate common interests in order to achieve a solution.

As Carlile has provided in his prior research, insights into the different the types of knowledge managed (Carlile, 2002) further elaboration is given in how these knowledge boundaries facilitate resolution of novelty via transfer, translation and transformation processes. Carlile introduces a 3-T framework that categorizes these boundaries and the respective processes that manage these boundaries (Carlile, 2004). This framework, shown in Figure 2, provides a representation of discussing the different types of boundaries exhibited within an organization.

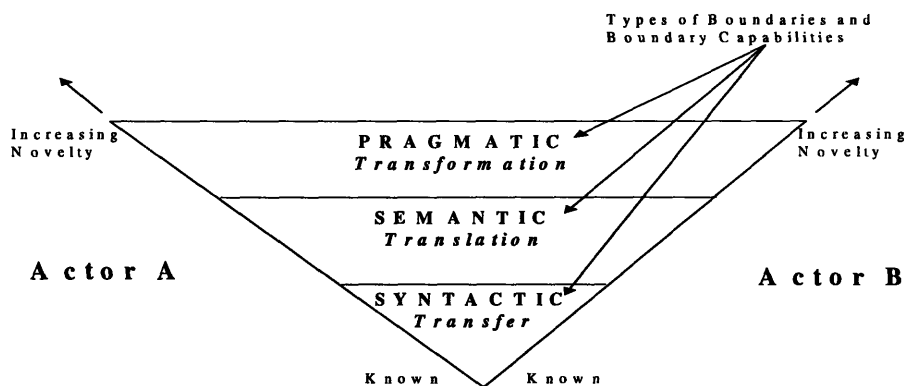


Figure 2 - 3-T Framework for Managing Knowledge across Boundaries

Novelty is new and/or changing knowledge that does not have a frame of reference, or environment to be quickly understood. It, or the situation is something different from the normal method of operation that requires the participants to identify, address, internalize and resolve. If the level of novelty between two participants increases, the movement of knowledge across the boundaries changes. The Syntactic boundary requires stable conditions, and a recognized common syntax that is used by the participants to facilitate sharing and assessing information. This process is referred to as transferring knowledge. The Semantic boundary occurs when novelty makes recognized meanings ambiguous, and differences in knowledge and dependencies are not known. The process of creating a shared meaning from different interpretations and relevancies of knowledge into a shared meaning is known as translation. The last and most difficult boundary to manage is the Pragmatic boundary. This boundary occurs when the novelty present causes different vested interests among the participants. The transformation process develops common priorities (when participants vested interests are disclosed) to facilitate knowledge sharing and transference. Shared artifacts, methods and boundary objects aid in the transformation process by providing the capacity to compromise.

The 3-T Framework links the relationship, of novelty with the increasing complexity of managing knowledge. Carlile's 3-T Framework creates a categorizing system for describing the situations that can occur between the type of boundary encountered, and the type of process employed.

2.3.4 Hierarchy of Novelty

In Gilbert's work, a proposed hierarchy of novelty using the 3-T Framework is given (Gilbert, 2004). The hierarchy shown in the figure below is elegant in providing four defined categories for varying degrees of novelty during product development.

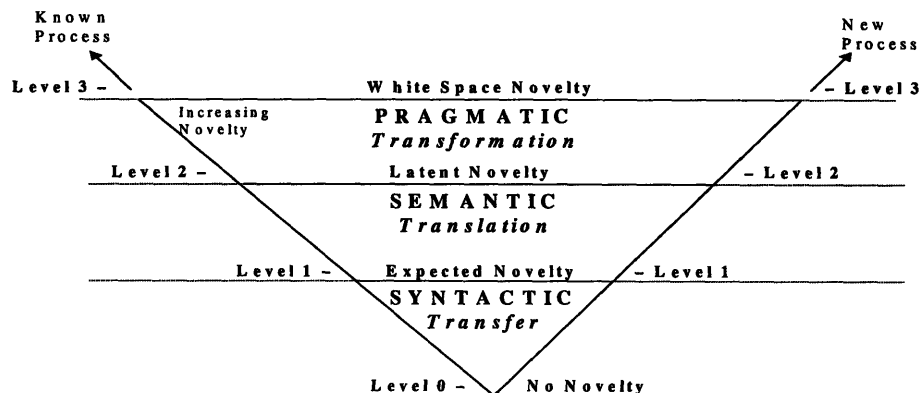


Figure 3 – Hierarchy of Novelty

Definitions for the levels are as follows:

Level 0 – "No Novelty"- Constant

This level describes the syntactic transfer of knowledge –information is predictable and stable. Organizational processes and dependencies are known, understood and relevant processes, and existing organizational infrastructure, capacity and ability are capable in addressing the situation.

Level 1 – "Expected Novelty" - Sustained

This scenario addresses the situation that novelty is anticipated or expected. Novelty alters the system's behavior from expected norms. Modifications of the information and the involvement of more participants and actors are required to facilitate the semantic boundary and the translation of knowledge. The existing organizational infrastructure (having sufficient capacity) requires translation to specifically address the expected novelty. This infrastructure is augmented to fit the context of the new system. These incremental advances to a stable organizational infrastructure strengthen the organization's capability.

Level 2 – "Latent Novelty" - Evolved

The system becomes altered due to the impact of novelty on areas. The novelty is undetected, underestimated, unanticipated or assumed to align to normal methods by the participants. The novelty encountered does not align to predictable outcomes or –organizational infrastructure, therefore processes are unable to process this new dilemma. This boundary requires new participants and resources outside of the familiar process. The system capability becomes altered to accommodate the modification and/or creation of new methods to resolve the novelty.

Level 3 – "White Space Novelty" - Created

This final level defines novelty that is so foreign to the system that no existing processes can drive resolution. Significant learning is required by the participants in order to develop an infrastructure and process to support this novelty.

This hierarchy tool will be used in discussing the types of novelty encountered in the case studies, and also used in the triage –the final indicator of the levels of novelty an organization can anticipate and manage.

2.3.5 Adaptive Learning

Tyre and von Hippel describes adaptive learning as a situated process that the ability to understand and resolve problems is due to: the information that participants have; the ability of participants to recognize and enact clues about the problem or its solution, and utilization of resources and gathering information embedded in a particular setting. Adaptive learning investigates resultant behaviors, technologies, or beliefs undertaken in response to negative feedback.

"Actors frequently move in an iterative fashion between different organizational settings before the identification of the causal underpinnings of a problem and selection of suitable solutions" (Tyre, von Hippel, 1993). More specifically, the adaptive learning process has a social knowledge exchange that is facilitated via discussions, arguments and collaborative "sense making", but the process also depends on the impact of the surroundings. Actual setting or location can equally be as important in problem solving.

This information is used to better understand the boundaries involved when working across organizations. Seeking beyond the physical setting or local department can create different solutions and innovation based on the knowledge shared.

2.3.6 Corporate Strategy

Information gathered shows key correlation of company technological and overall performance to strong relationship between technology and business strategies, the relative 'newness' of the technology, the perceived technology leadership, and decreased time to market (Roberts, 2003). A company's strategy is important to understand the actions employed to counter new technologies and changes. A strategy becomes dynamic –the anticipation of market trends and quick response to ever changing consumer needs.

To provide a better explanation, a strategy of a company is the organizational knowledge creation, the organizational capability of acquisition, development, and accumulation and exploitation of knowledge. A corporate strategy is a vision, that conceptualizes the knowledge that should be nurtured to strengthen the company's position, and the corporate strategy develops a means of making it operational into a management system for implementation.

A company's 'nimbleness' to react to changing consumer needs becomes increasingly more difficult to manage if the company relies solely on its core competencies.

2.3.7 Core Rigidities

Core competencies come from technologies, workforce skills and the capacity for action. The interaction of four elements determines how effectively organizations exploit these core capabilities. The four elements are: knowledge and skills (technical 'know how' and/or personal 'know who'), values (norms, attitudes and behaviors), managerial (e.g. methodologies, incentive programs), and physical systems (e.g. plant, tooling, equipment). Core rigidities develop from core competencies (Leonard-Barton, 1994). This concept originates from the fact that companies over time gain efficiency by streamlining processes, and developing skills to support the needs of their consumers. This concept is only successful under unchanging stable conditions. However if unstable, the organization that relies on its core competencies is not successful in adapting to new market conditions, technology and innovation.

'Resting on their laurels', a company's traditional success becomes a weakness to the development of new capabilities. Over time, the company's core capability becomes a core rigidity. Because the company cannot adopt to dynamic conditions, and novelty and new inputs, the process becomes indoctrinated. Based on the theory of organizational evolution, "adaptation precludes adaptability". Due to over adaptation from past success, the company fails to 'unlearn' those success factors within a new and changing environment. For instance the dinosaurs evolved into creatures both physiologically and morphologically suited to the present environment. However these creatures over adapted to this specific environment and were not able to alter themselves to climate variations and scarce food sources. Companies, akin to dinosaurs that become too complacent with their core capabilities, may also follow extinction.

Organizations can overcome core rigidities by using development projects to modify their skills, and behavior to expand these core capabilities. Leonard-Barton explains that an incremental approach, that focuses on all the participants of the product (e.g. development of the manufacturing and assembly of the product), and that continually challenges conventional thinking by tapping into other resources enriches the core capabilities. This requires a coherent vision, leadership and organization to generate knowledge development and foster the core capabilities.

The process to invest in new products or services begins inherently with the vision statement of an organization. The culture of the organization drives the decision-making process where no process, or documented steps or evaluation criteria exists. If the company becomes rigid, it lessens the company's core capability to grow when encountering new inputs. Not all novelties can be managed within the organizations core competencies. When encountering novelty, the organization needs to identify that the existing core competency does not support the novelty – and have the flexibility and environment to encourage, and manage these novelties. With any large organization it requires time for the "head to move the body", and Leonard-Barton's work discusses these difficulties in modifying the core competencies as core rigidities.

2.4 Summary –Where This All Fits In

In order for the reader to understand the terminology used repeatedly within this document, the definitions are provided in the first segment of this section. These definitions are of prime importance for without these definitions the syntax, made by the reader would have entirely different meanings for the words used. Different types of organization are explained throughout

the second portion of this segment, in order to later identify (specifically during the review of the case studies), whether a particular organizational structure is evident. The last segment of this section specifically addresses the literature reviewed in formulating the thesis topic.

Virtual knowledge describes the process of how people transform information into knowledge. Large gaps in understanding are identified when participants are not recognizing the same meanings. These gaps make the knowledge creation difficult to occur. Carlile's 3 - T framework provides additional elaboration into the various types of boundaries when novelty is encountered and the processes by which information is changed into knowledge. The work from Tyre and von Hippel supplies further support of Carlile's work, and also indicates that adaptive learning is impacted by the organizational structure and setting. Gilbert's work augments Carlile's by segmenting and classifying the types of novelty encountered at these boundaries.

The necessity to have a corporate strategy is imperative for company's to align the infrastructure to its goals and. Core competencies are further strengthened in order to support or advance the company's market share and position in a relative industry. However, Leonard-Barton's research does indicate that core competencies become rigid instead of strengthened when processes are streamlined. Novelty encountered in some instances cannot be 'pigeon holed' into a specific process. Thus an organization needs to be able to identify the novelty introduced, and react to these changes by having the appropriate flexibility and environment.

The Familiarity Matrix establishes an approach to plot a company's familiarity with respect to the market segment and the technology being leveraged. This matrix has been used in the past for determining the strategic positioning of a company in relation to its competitors. However, when utilizing this matrix to plot the novelty encountered by these changes with respect to the market segment, the author postulates that the type novelty as introduced from Gilbert's work and the boundaries involved (from Carlile's research) can be predicted.

3.0 SETTING

The studies discussed in this paper are from automotive design and manufacturing companies. The particular automotive manufacturer has had many recent organizational changes reacting to decreases in its market shares, and a weaker market economy. This company has realigned itself by restructuring platform and engineering system groups to develop core competencies and expertise. The product development method currently employed is based on reducing time to market by following best practices and using concurrent engineering. This process, has not delivered to its projected expectations (reducing its timeliness to market) thus a new product development process is forthcoming.

In comparing 30 North American single product-single plant launches of automotive manufacturers from 1992 – 1996 (Smith, 1998) the results indicated:

- An average performance of vehicle launches, the facilities operated at 85% before the changeover, and took 4 months from the start of production to return to the previous 85% level
- Honda was the quickest –indicating far smaller production variation during the changeover period, next was Toyota
- Ford Motor –had steep drops during changeover however, rebounded quickly back and exceeded prior capacity levels after one month
- Chrysler and General Motors had the most severe drop in changeover, and the longest ramp-up performance (6 – 8 months to return to capacity)

Current trends prevalent by all industries evidence an interesting pattern development (Roberts, 2003):

- Reliance on external sources of technology –over 80% of Japanese, European and North American companies have this unique characteristic
- Measurement of average maturity of key technologies, Japanese have the most mature technologies whereas North American companies have the youngest
- Increased time to market, Japanese lead with nearly twice as many to European companies, and five times the number of North American companies
- Reliance highest for North American companies on managerial practices: multi-functional teams, stage gate product, project managers, simultaneous engineering, senior management sponsors and CAD/CAE

"Company sales growth is statistically related to research and development meeting its multiple project-level objectives of schedule, technical performance and budgeted cost" (Roberts 1993). To address this, North American companies are decentralizing control of research and development functions to the business units, while Japanese companies are shifting the pendulum in the opposite direction (Roberts, 1993). From a short-term performance standpoint-decentralizing control provides advantages of increased ability to implement changes in current product lines, and quick reactions to consumer needs. However, if prolonged this shortsightedness can eventually lead the company to be vulnerable to technological blindsiding, erosion of core capabilities, and less creation of new core strengths.

Although there appears to be some improvement, it is also important to note that longer production development cycles times and launch delays, result in longer 'time to market'. The trends mentioned, in addition to changing government requirements; evolving technology; and increased competition has led to changes in the way business has been conducted in the automotive industry, during the past decade. Consumers demand products with more content at a lower cost with shorter production cycle times.

Design is recognized as the primary contributor of the final product form, cost reliability and market acceptance. The high amount of engineering and design analysis in the definition/feasibility, and the development/integration phase becomes extremely important since the majority of the life-cycle costs and overall quality of the system are determined during these phases. The most considerable opportunities for cost savings occur during the earliest phases of a product. It has been identified that approximately 70% of the life-cycle costs are frozen by the development/integration phase (Calkins, Su, Chan, 1998). To reduce automobile time to market, this information supports the need to shorten the early stages of a product design cycle.

Technological, and economic trends indicate that the area of advanced manufacturing (a.k.a. product development) provides the most promise for traditional automotive manufacturers to compete effectively in a dynamic market place (Daneshgari, 1998). Organizations have examined several aspects of their product development cycle looking for opportunities to increase the response time through planning methodology, organizational structuring, and communication tools. To compete, automotive manufacturers must develop a community that employs lean, flexible or agile practices. This paper will explore the current organizational structuring and the communication tools utilized for systemic agility, to speed up response time (and thus lessen time in early stage development) and the impact of managing novelty.

4.0 METHODS

4.1 Motivation –Theoretical Questions

The modification of the product development cycle of automotive manufacturers was to reduce time to market. However, current trends have indicated that North American automotive manufacturers are not delivering to this objective. To support this trend, the Body Engineering Interior Trim department (of a North American OEM) approached the author to solve the causes for delays encountered with the design, its feasibility, and development of interior systems.

To scope this broad topic, the author commenced to develop a value stream of the current design process. This tool did not aid in reducing the scope of the subject, however it provided insight into the number of interdependencies that are required to communicate across multiple boundaries to convey, translate, and change knowledge to the systems being developed. The author created an 'Is, Is Not' table and with Error Proofing analysis further narrowed down the scope (see Table 1 and 2, in the Appendices). Employing these tools, and the internal process to "Identify Errors" the author was able to find and identify the bottlenecks in the feasibility process. The thesis scope was then narrowed down specifically to case reviews, interactions among vehicle styling, design engineering and body engineering departments when proceeding through the design process, and its feasibility and/or development of an interior system.

Thus, the hypothesis of this paper postulates that organizations can be successful to identify, reconcile and resolve novelty introductions. Concurrently, different levels of novelty encountered are studied, and its characteristics are identified. Reflection of organizational dynamics to different novelty introductions would allow an organization to be aware of practices which allow/prevent the effective management of knowledge.

4.2 Approach

Actual experiences will be discussed to understand the impacts of different types of novelty on an organization. Research of this nature was chosen since recommendations developed in this paper are from induction of data, rather than proposing a general conclusion. Five case introductions are from various interior trim areas, their management of technology innovations, late knowledge additions and corporate strategy changes. Case topics were selected from four forward model programs, under competitive objectives and time constraints. Three of the case study subjects emerged from regular meetings with the Body Engineering Interior Trim Manager, the other two case study subjects followed from interaction with cohorts from the two other OEM's.

Data for the majority of these case studies was collected by using the triangulation technique, through interviews, studies of internal and external documents and sometimes by participation observation. The data was gathered over a eight-month period that included repeated (open-ended and semi-structured) interviews with participants and additional communication via email and telephone dialogue to clarify particular events. The personal interviews provided the core content of the information collected for the case studies. Supporting documents were provided as ledgers for the changing evolution of the product (reaction to the novelty). Participants for the

first three cases with OEM 1 were selected from the various departments and subgroups, shown in Figure 4.

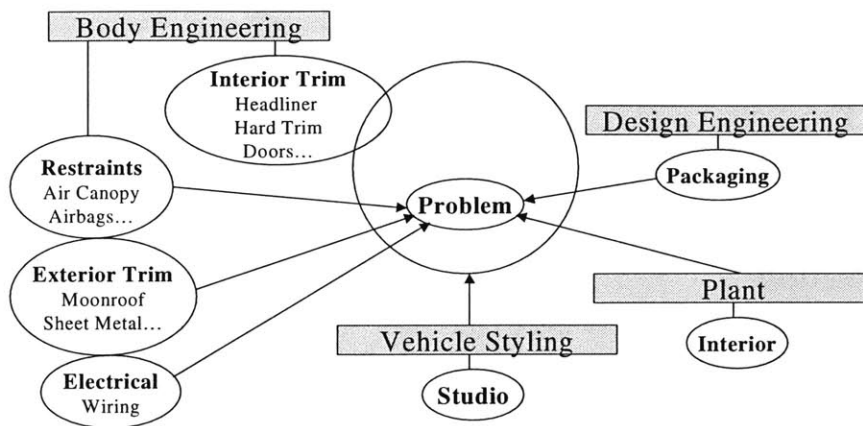


Figure 4 - Relation of Different Participants Involved for OEM's 1 and 2

The other two cases involved discussions with Japanese OEM's. The fourth case, from OEM 2, had an organization similar to the one shown above. OEM 3, had a different format, as shown in Figure 5.

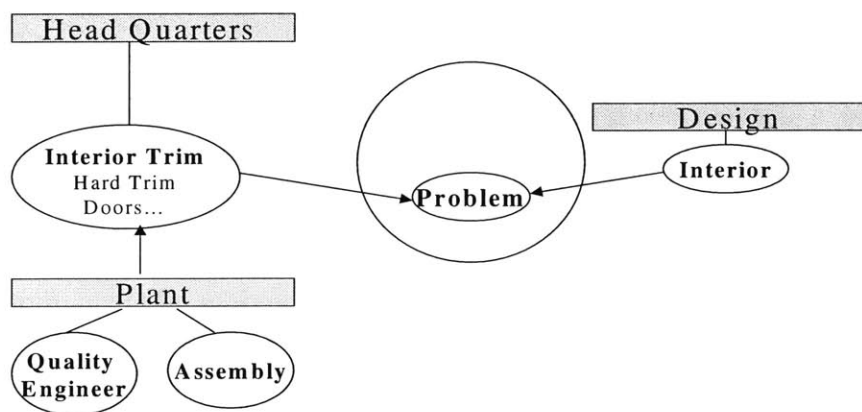


Figure 5 – Relation of Different Participants Involved for OEM 3

The cases identify different types of novelty, boundaries and the capacities found. Attention was given to: how the novelty was generated, what knowledge was gathered; the setting of the novelty, who identified the novelty, and which conditions/circumstances participants moved forward to resolve the novelty. The cases presented evidence team dynamics, the reconciliation of novelty under real life constraints.

For OEM 2 and 3 the author was unable to gather a more substantial pool of interviewed sources (due to travel constraints and time differences) thus the information is dependent on primary sources. This may lead to a biased view or offer misleading information of the process since other areas were not interviewed during this period. However, given the retrospective approach

utilized for the case studies, many factors mitigate concerns regarding the accuracy of data acquired. Specifically with OEM 1, the first factor is the interviewees independently identified the same problems. The second factor is the issues appeared to be memorable enough to facilitate a quick recollection of the events that led and resolved the novelty. This information was based on a high degree of agreement of the interviewees of the changes made, the iterations, and final solution. Lastly, the third factor is that the case studies and the novelty encountered were aligned to certain checkpoints of the respective programs that allowed the interviewees to reference records that documented the problem evolution. All of these factors show good correlation that the data acquired is fairly accurate.

4.3 Company Selection

Criteria for company selection were based on three rationales: ability to innovate, sustainability, and familiarity with market segment. From these reasons the Interior Trim area of the three OEM's were selected. The selected department had the core competencies to innovate, and react to fluid changing conditions by successful performance of their products. The strong market leadership and presence demonstrated that these companies had endured and sustained under competitive pressures. Lastly, this area was selected due to the author's familiarity and accessibility to these topics and participants.

4.4 Case Introduction

Consider the situation that new inputs of information are presented that affects the parts you are responsible for. What type of approach is implemented to address and internalize these impacts? Is there a more effective method?

Imagine this scenario, a problem area is identified and is communicated via email for the decision making experts to prepare for this discussion. The following week, all these specific actors fly to the destination of the meeting and once there, collaborate collectively for two hours to resolve this issue, along with 3-5 other major concerns. Discussion is mediated through a team leader and through the use of hard prints, or hand drawn sketches on paper or sketch board. Follow up assignments are captured on the sketch board and printed for all the participants to view. These assignments are then reviewed at the next meeting, when the design proposed is further reviewed, thereafter approved, and eventually incorporated into a final design. Readers may snicker and believe this technique is rather archaic and ineffective, however the OEM employing this approach has consistently beaten Ford, General Motors and Daimler Chrysler in quality and time to market their products. How is that possible?

The "keys" are the *means (the methods)* and *structure* for managing novelty. Novelty can be seen in many forms, and appears in each of these cases. It is the change encountered when products, features, and/or situations are not the same. Novelty produces positive consequences since it creates innovation. However, during the transition period when the novelty germinates into an innovation, it is not perceived as a beneficial impact. In most situations, novelty requires a trade-off in capacity of a subsystem's feature and/or performance. The critical need is to assure development and have an agreement to trade-offs of the subsystems.

The novelty shown in the first case describes the impact of a late program decision to add a feature that affected 'frozen' appearance designed parts. The change impacted the fixed

(physical) part boundaries and the case will evidence how the team was still able to incorporate this late feature addition. Another case involves the underestimation of the amount of change required for a new feature that impacted many subsystems. This novelty although anticipated by the program, the ramifications to subsystems affected were not fully understood until later during the feature development. The novelty therein led to delayed production tooling kick-offs. In the third case, the 'unknown' of an entirely new design, based on a corporate initiative will be reviewed. The novelty presented in this example will be the most challenging since expected realms and parameters defined by subsystems still need to be re-negotiated. All the subsystems impacted require joint coordination and agreement to develop a suitable design to resolve the introduced novelty.

The other two remaining cases will show how Japanese automotive manufacturers manage innovation. The fourth case, involves the impact of changed program direction due to a significant amount of change, the novelty although anticipated still led to a postponed launch date. The last case involves the ramifications of a new design and how the styling changes impacted the assembly and installation of the part and its supporting systems.

Cases presented are taken from four forward model programs that will be referred to as "Program B", "Program C", "Program N", and "Program T". Program A, B; C and N are variants from existing vehicles. Program A, C; N, and T all have program assumptions for entirely new interior environments. Program B has a similar interior environment as Program A with the exception of the rear portion of the vehicle. The content, suppliers changed was based on the product assumptions created.

Additional logistics to clarify is that the product teams develop a product system that is to be packaged within the larger environment, the vehicle. The "product" used in these cases will describe the subsystem, while the word "system" will be used to encompass the complete units to deliver functionality and performance.

Some content of the case studies have been omitted to protect information that has been deemed confidential by the company. Information removed or altered has not degraded the 'flavor' or the dynamics involved when managing the novelty in these scenarios.

4.4.1 The First Case – "Late Addition –Satellite Dish Radio Antenna System"

The first case involves the novelty from late program decisions. Late content driven features were given to Program A and Program B. Unfortunately due to the timing of this program direction, Program A was unable to incorporate this feature into their vehicle until after the program launched successfully. This was due to the fact that the production tools for the subsystems affected had already been kicked off. Program B, however had not kicked off tooling. To avoid delaying Program A's launch, upper management decided to include this feature first to Program B, and then later add it to Program A. Program B received this addition at the end of the last design checkpoint, prior to tooling its kick-off.

As a result, assumptions in the beginning for Program B did not call for subsystem changes for this feature. The addition of the satellite dish radio antenna system (dubbed with the acronym, SDARS) created the novelty. This feature had to be added and packaged to an existing

subsystem. Program direction for the packaging of this feature was not specified. Problems arose in defining the precise location for the residency of this feature on the roof. Some of the areas investigated were the rear, and the front of the vehicle. The location was eventually finalized to be in the front of the vehicle, to have a common location for Program B and A (since both would be built in the same assembly plant). The existing program infrastructure supported the package accommodations for this feature. The created novelty required anticipated changes with other components, once the final location was determined. Because of its size and scope of the novelty, it was easily managed within the core competency of the organization.

The program assumptions, cost, and tooling investments were modified to protect the subsystems effected by this change. The SDARS had to package within subsystems that had already finalized the majority of their respective designs (styling, and other subsystems). This meant the SDARS feature had to package within the existing constraints of the subsystems. Parts, which were already fixed, were unable to be modified radically without impacting safety, assembly installation concerns, or other dependant subsystems. Modifications occurred within the subsystems impacted, since the program protected and anticipated investments for this content addition. Even though this forced feature addition created the novelty, the situation was later resolved and incorporated successfully into the vehicle design using the existing organizational infrastructure and capability.

4.4.2 The Second Case –"Safety Canopy System Technology Impacts"

The second case involves the novelty of new technology. New technology was driven by new government requirements for rollover coverage that translated into corporate regulations. As a result, assumptions in the beginning for Program B called for safety canopy coverage along the entire side periphery and the rear of the vehicle. In this situation the safety canopy system created the novelty –since no prior vehicle from this company was known to have successfully packaged this feature. Problems regarding the feasibility of the safety canopy system began during the second (out of five) design checkpoints along with the package environment required to accommodate this technology. The existing program infrastructure supported the air canopy coverage design along the side periphery, however, the coverage along the rear and back of the vehicle created a serious crisis.

The crisis was created due to unanticipated changes required to other components. The safety canopy for the rear of the vehicle was understood to package along the C-pillar hard trim similar to the carry-over design (carry-over part is defined as something that does not require any type of design changes). Unfortunately this location was not feasible due to the negative impact on the performance of the safety air canopy thus, it was relocated to another region (the upper portion of the C-pillar, rear garnish and headliner).

The program assumptions of cost and tooling investments were assumed to remain unchanged for these subsystems, which meant that technology would have to package within the current design. This assumption was shown to be unrealistic. Other than the safety canopy, the program direction for the content in this area was to remain relatively unchanged. The subsystems were required to be displaced or changed to package the new canopy. As a result, the suppliers of these components requested funding allocation in order to accommodate and generate a feasible

design to capture this technology. While components contributed to the latent novelty, the situation was later resolved and incorporated successfully into the vehicle design.

4.4.3 The Third Case – "Corporate Strategy –Overhead Consoles"

All the established boundaries of the overhead system become open for discussion. In this case, a new corporate initiative of the company affected Program C. Due to the timing and launch of Program C, it became the originator in getting the new overhead console. All subsequent 19-vehicle lines within the company will use this same console. However, the actual problem was that the console was not designed! This part influenced other systems in many ways. Content that may have resided in this area is either eliminated, or displaced to other locations. This case goes through the critical development of this overhead console and its incorporation within Program C. The novelty presented here, is a result of a corporate strategy to reduce complexity in all the programs by means of reuse of a central system in this case, the overhead console throughout the various programs. As a result all prior assumptions are invalid. The old supplier of the overhead console had been ousted, and a new supplier sourced. Problems with the sourcing of the overhead console resulted in issues of conforming to Program C's timing. Console sourcing was not relegated until after the last design checkpoint of Program C. Program assumptions called for the new overhead console strategy however, the supporting infrastructure had to be augmented to deliver the product within Program C's timing plan.

Referring back to Figure 4, there are many participants involved with this design. In addition to the participants shown in this figure, another group central to this case is necessary, the Strategy Commodity Team (SCT). This team consists of two supervisors who are required to develop and design the strategies that impact programs from input of studio, interior and overhead console suppliers. The team is required to establish the design as the content for the system. However, this is not how the situation unfolded. This team attempted to leverage five suppliers to develop the design of the console. Design development was very costly, yet the 'carrot' the SCT dangled was that one of the five suppliers would be awarded the business for all the platforms for this overhead console.

From the beginning, Program C had a program direction letter whereby it was to incorporate this new overhead console. Due to this assumption, the headliner and overhead console systems were assumed to be new for the program. Program assumptions, cost, tooling investments and resources allocated for these subsystems were assessed to be adequate for the new design. This optimistic assumption proved to be faulty since later during early development additional resources, and funding were required for the prototype overhead console parts. The program assumed the overhead console design was more or less fully developed and designed and would be easy to incorporate into Program C. However, that proved untrue. Program C utilized abundant engineering resources to create a feasible design.

Therefore, the novelty seen in this case study was created due to the 'white space', or the lack of constraints involved with the overhead console design. More novelty was further introduced in the form of the SCT that had complete power of the overhead console design, yet failed to fully deliver a product, which could be incorporated into Program C's vehicle. This case introduces the issues involved, and the tactics taken to manage the novelty of the overhead console design, and its incorporation into the program. While the overhead console and its components created

novelty, Program C's team using input from the SCT and other subsystems, created a design that was incorporated onto Program C's vehicle.

4.4.4 The Fourth Case – "Rear Glass and Sheet Metal –Late Change"

This case deals with an entirely different automotive manufacturer, and later timeframe of part and vehicle development. Program N is a truly 'global' program. The early design development for the program began in North America, and then the majority of the prototype is built and assembled in Japan, with final production being in Mexico. The novelty faced in this situation happens after the production-tooling event, and during the timeframe of the first build event. The build event, arbitrarily called QP, spanned approximately two months. Some of the early vehicles from the QP build were sent to a customer insight clinic, and the exterior appearance of the vehicle was poorly received. The program N needed to choose whether to proceed with the existing designs, modify, and/or create new designs to address this problem. The program decided after careful consideration from reviewing proposals, to modify only the rear exterior appearance of the vehicle. This decision, akin to the domino effect, drove changes inside the vehicle interior. This case involved the novelty of developing a new interior part (the C-pillar hard trim) to accommodate the sheet metal and rear glass designs that were required to make the vehicle more aesthetically pleasing to the consumer.

Novelty arose due to these unanticipated changes. Selecting the correct appearance for a future product carries some risk to identify with the targeted consumer profile. As a result, late program decisions mandated entirely new parts and tooling. Due to the timing of Program N (launch date of summer 2005), the suppliers were quickly informed regarding the systems impacted by this exterior change. Based on the scope, and specified location, the suppliers were given the task of designing new parts.

Changes in the rear glass angle and the sheet metal, the overhead system, hard trim and the package tray required modifications and/or entirely new designs. Due to the critical timing of the program, the automotive manufacturer solicited designs for the specific parts. In the case of the C-pillar trim, the design changes the supplier recommended were accepted with minor modifications. C-Pillar new design required modifications for new attachment points (to sheet metal) and an entirely new shape and interface due to the movement of the safety canopy design. The existing program infrastructure supported the C-pillar and other subsystem design changes however instead of complete derailment of this vehicle launch, Program N had a 9-month delay resulting from this novelty introduction.

4.4.5 The Fifth Case – "Tweeter Design"

OEM 3, another different automotive manufacturer, will be the last case study reviewed. This case will study the North American Program T, entirely new vehicle with new exterior and interior systems. The novelty confronted occurred at the end of the first stage of development. During this stage, arbitrarily called Stage 1, manufacturing had identified during the drawing reviews an installation issue with the newly designed tweeter to the mating systems of the sheet metal, interior, and electrical systems. Program T had to develop a solution by either modifying the existing designs, or creating a new design to address this problem. After careful consideration from reviewing proposals, the consensus decision at the end of Stage 1 was to

modify the sheet metal, with interior and electrical components. Novelty had transpired, and the developed design seen at Stage 3, still had not resolved the installation problems.

Novelty arose due to styling changes in the interior component, which affected the functionality of the proposed design as determined in Stage 1. Sets of design proposals among the manufacturing, electrical and the interior systems were developed to address this problem. From these proposals and the constraints of the system the final solution decided by the team, required modifications to the wiring harness (electrical), new attachment points (to sheet metal), and redesigned A-pillar back surface for tweeter attachment. The existing program infrastructure supported the new tweeter design and with other subsystem design changes, remained on track for meeting the program's timing deliverables.

5.0 CASE STUDIES

5.1 The First Case – "Late Addition –Satellite Dish Radio Antenna System"

5.1.1 Background: What is a Satellite Dish Radio Antenna System?

The satellite dish radio antenna system, known by the acronym of SDARS is a feature that provides the consumer the accessibility to have and choose from various arrays of radio frequencies (channels). This feature is very similar to SIRRUS. The SDARS was added to the Program B to remain competitive in a new technology market. In Figure 6, highlighted in yellow is the SDARS system. This is an electrical feature that requires a wire harness, connectors and an antenna mounted to the roof.

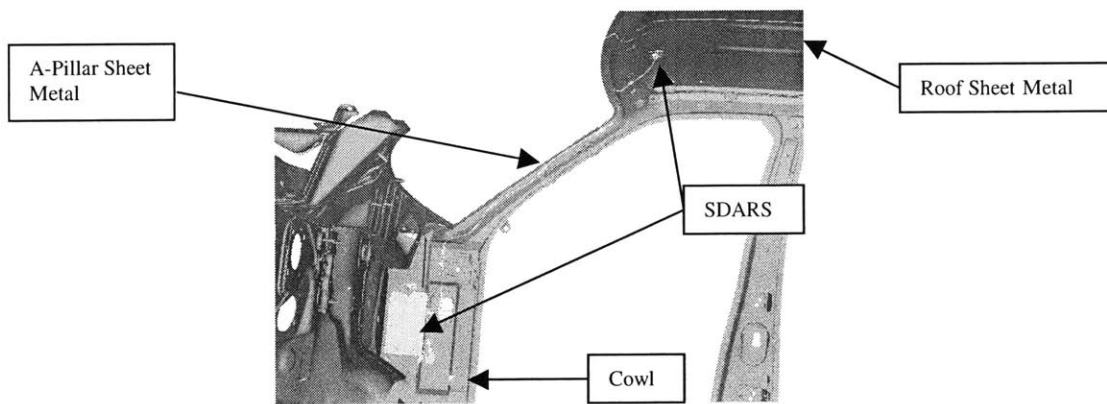


Figure 6 –Illustration of Location of the Satellite Dish Antenna System

This figure presents the final 'home' of the SDARS. Prior to this, the SDARS was proposed to reside in the rear of the vehicle. The SDARS incorporation required to package behind other subsystems (e.g. the headliner system, cowl, A-pillar trim, safety canopy system).

5.1.2 Novelty Encountered in the Satellite Radio System

Prior to this late addition, all the subsystems of the vehicle were not affected. However, when this feature became the program direction, a location had to be established. Based on the SDARS requirements, the sheet metal of the roof, and the headliner were assumed by program direction to have some modifications in incorporating this feature. These assumptions were made based on past common knowledge and experience with packaging past electrical features in the vehicle. Novelty was created when the SDARS was introduced to the program. Final actual location scoped the magnitude of the changes involved to other subsystems since the program had a core competency with this type of novelty.

Suppliers sourced for these affected parts remain unchanged, with the exception of the new electrical wiring supplier of the SDARS feature, and the new antenna supplier. All however, had

some relative experience with the company's product development cycle, and familiarity with the nuances of this program's process and its key participants.

5.1.3 Relationship with Other Systems

Once in the program assumptions, the SDARS was originally slated to reside in the rear of the vehicle. This SDARS destination was changed due to performance and manufacturing constraints. This included a requirement to have a minimum of a flat six-inch radius area (from the antenna to any edge of roof) for antenna functionality, and another requirement for accessibility of 25 inches from outside of the vehicle for installation (maximum installation reach zone). The latter requirement was required due to the late addition of this feature, the automotive assembly plant was required to install this SDARS wiring prior to the headliner installation. As a result of these constraints, and many reviews, the rear location of the vehicle were eliminated, and the front area of the roof was determined to be the best optimal location for this feature. Specifically, the final location was determined to be on the front passenger side of the vehicle. The decision of this location was due to the wire routing of the SDARS, and the unavailability of package space in the driver side area. Additionally, this location was common between Program B and A. With the location finalized for the antenna, team interactions began to determine the attachment points in the sheet metal for wiring, and package clearance checks to avoid interference with the headliner and hard trim assemblies.

Due to the fixed dimensions of the SDARS feature, and the established designs of the sheet metal header, headliner, and hard trim, changes to these systems were relatively 'known' and understood. The header had to verify that the locations requested by manufacturing were feasible to be incorporated from a "part" and safety standpoint. The headliner, which mates up to the sheet metal header and the A-pillar hard trim had to determine the greatest amount the system could compress without degrading its performance. The A-pillar had to confirm that the wiring routing behind it, would not interfere with the safety canopy performance. Each of these issues was brought to the team's attention during the frequent package reviews.

The cascade effect occurred however no radical changes were required that impacted dependant subsystems, just more refinement on an existing design. For instance, the connectors were assumed to reside underneath the headliner system, however to repair the SDARS feature, required bending the headliner system to access these connectors. When it was announced by the headliner supplier that this location would require the entire headliner to be dropped for a service repair issue, the connector was relocated to the passenger side A-pillar. This location was favored since a \$154 cost was incurred just to remove the headliner in order to do a diagnostic check (2.2 hrs removal time = ~ \$154). Thus, the headliner, A-pillar and sheet metal header subsystems had minor modifications that were manageable to change within their respective designs.

However, with any late additions there are some unexpected risks associated with quality and performance. Due to package space limitations to accommodate the SDARS wiring between the rear header and the headliner systems, there are risks for rattles (in the locations that the wiring is not secured), and quality concerns if the wiring is pinched, due to too much interference. These risks have been identified and carried by the program until subsequent build evaluations. If these risks prove to be validated, the program has allocated investment to resolve these issues. Styling

involvement was not needed since these changes did not impact the A-surfaces (this is the surfaces of the part that is seen by the consumer). Production tooling was contained, and kicked off on time.

5.1.4 Objects/Artifacts

The participants impacted by this change attended only one meeting to resolve this issue. The digital buck was the primary medium for capturing the design changes for all the subsystems. Changes once completed, were reviewed at the meetings to determine infeasible assembly issues arising from the SDARS location. E-mail was also used to send basic messages, when business in person was not available.

5.1.5 Ends/Results

The SDARS location and packaging were determined by the critical requirements needed for this feature. The sheet metal header had minor modifications to accommodate attachment points for the wiring installation. The headliner and the A-pillar hard trim required revisions to the back surface of their respective parts. All these changes were successfully incorporated into the subsystems prior to production tooling kick-off.

Due to the necessity of packaging the SDARS on the roof, the subsystems associated with this system recognized a potential impact of the SDARS to their respective subsystems. The areas modified in the headliners and the A-pillar was anticipated due to the program direction, and familiarity with the electrical system and their consequences (potential number of driven changes). None of the subsystems impacted by this change had any more influence over the other in relation to the SDARS incorporation. All these parts had established final locations and packaging regions, and attachment schemes as recognized by all. No hierarchy of importance was needed or required to facilitate the changes to capture the SDARS feature, however the electrical system provided the most flexibility to change and adapt to the new environment, since the other impacted systems were almost completely fixed in design and ready for production.

5.2 The Second Case "Safety Canopy System Technology Impacts"

5.2.1 Background: What is the Safety Canopy System?

Not many individuals read the owner's manual for their vehicle, but these guides provide some insightful information about the system. The following were excerpts from an Owner's Manual in current vehicles equipped with the safety canopy feature. The Safety Canopy System consists of the following:

- An inflatable nylon curtain with a gas generator concealed behind the headliner and above the doors (one on each side of the vehicle)
- A headliner that will flex to open above the side doors to allow the canopy deployment
- Two side crash sensors mounted at the base of the B-pillar (one on each side)
- Two side crash sensors located at the C-pillar behind the rear doors (one on each side)
- Roll over sensor in the restraints control module (RCM)"

This canopy is a side air bag curtain that deploys from the edge of the headliner and protects both front and second row passengers during a side collision or a roll over. This system is activated under sensitive time frames, and is packaged behind the headliner (the interior roofing), and the hard plastic pillar trim. The figures show a side air curtain deployment from the A-pillar (the

front of the vehicle), B-pillar, to the C-pillar, the hardware required for the safety canopy system.

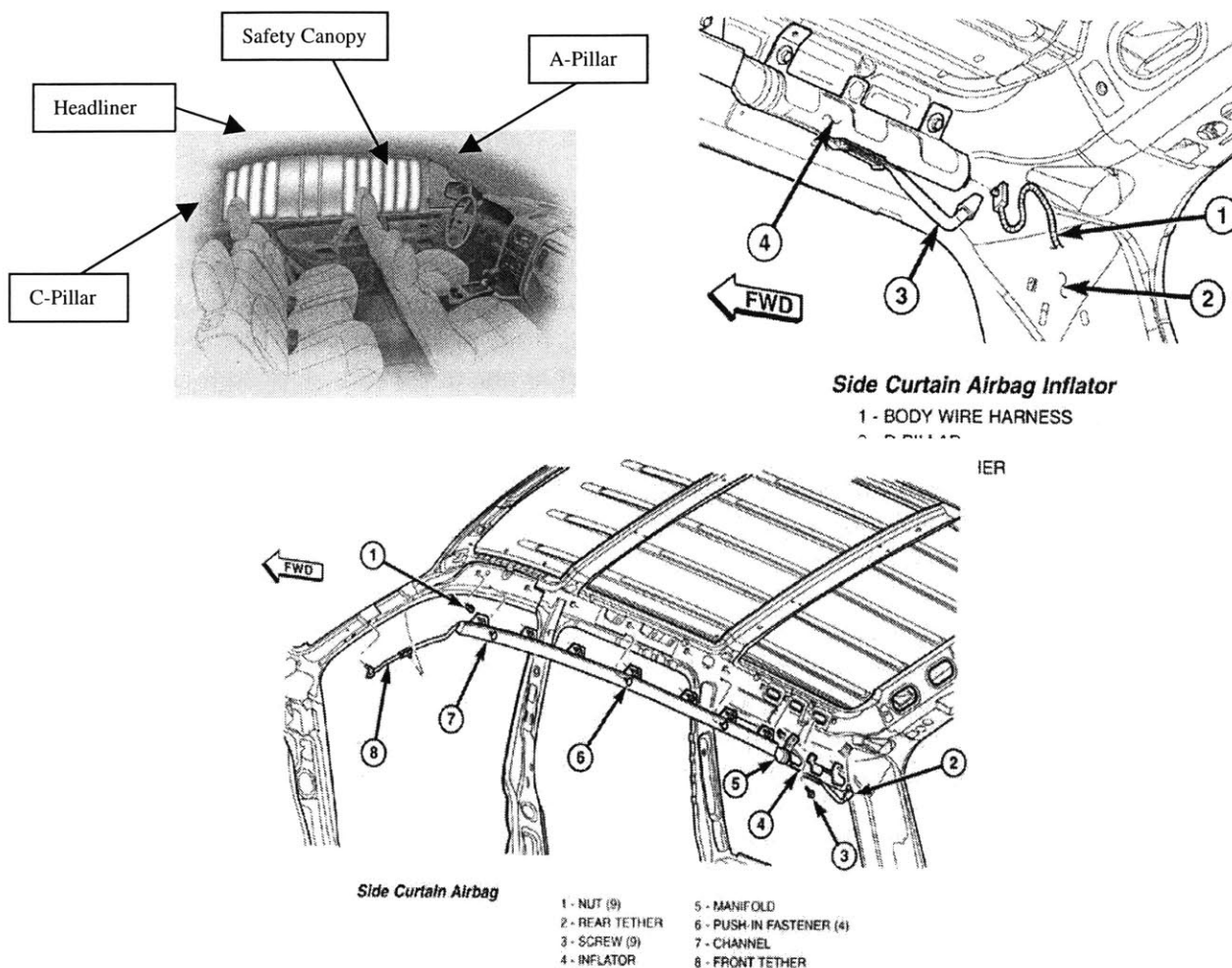


Figure 7 –Illustrations and Location of 2002 Jeep Cherokee Parts Associated with the Safety Canopy System

The air canopy functionality becomes more challenging due to additional components that are required and packaged on the headliner system (e.g. coat hooks, grab handles), or behind it (e.g. coat hook brackets, moon roof drain tubes, wiring, and climate control ducts).

5.2.2 Novelty Encountered in the Air Curtain System

The sheet metal of the roof, and the rear garnish (upper hard trim above a lift gate) were assumed by program direction to remain unaffected by the new air canopy system. The headliner was to remain as carry-over (the same as Program A), except beyond the 2nd row coat hooks where new designs were in the product assumptions to protect for the changes from the canopy system and differences between the vehicles. These assumptions were made based on past common knowledge and experience with the safety canopy package and its performance requirements. Novelty was created when the safety canopy design changed to a new location, and to something

different not encountered before thus negating the existing boundaries and knowledge relating to its design.

The suppliers sourced for these parts were the same as the prior program with the exception of the air curtain, moon roof, and wiring systems. All three of these suppliers were experienced with the company's product development cycle, yet they were unfamiliar with the nuances of this program's process or its participants.

5.2.3 Relationship with Other Systems

Beginning with the second design checkpoint, the air canopy system began changing designs (e.g. number of inflators, the dimensions of the inflators, the angle of the ramp) in order to bend along the back and rear of the vehicle. Bending a corner was revolutionary for the air canopy system since no other OEM was able to achieve this feat. Prior to this, the norm was to utilize a linear air curtain design along the side rails, ending either at one of the pillars, or beyond it. These two requirements: more package space, and 'the bend' caused the air curtain design to vary in: 1) the angles of the ramp design, 2) bag packaging 3) the size & location of the inflators required to deploy. These three factors changed independently or co-independently with one another. In hindsight, no other OEM's employing this feature may have been a good indicator for the difficulties that later surfaced.

Each one of these air curtain iterations created a domino effect. The headliner, rear garnish, sheet metal and all the other subcomponents had to modify their respective designs and assess part feasibility for all the evolved changes of the air curtain design. The inflator dimensions and its respective location necessitated roughly three months of discussions among the various departments (headliners, hard trim, sheet metal, etc;) until this canopy design could package smoothly in the environment.

Additionally, other constraints restricted the amount that the parts could vary. For example, the headliner part was assumed to change; however it was not allowed to protrude greater than current headspace conditions which created a restriction for all the components packaged behind the headliner. These headspace conditions were also given later than expected with an incorrect location, which caused the headliner tools to be kicked off late.

If any of the components changed, all other systems would be modified again and reassessed for feasibility to performance, part manufacturability, and re-design for appearance approval. Ongoing surface appearance development with vehicle styling was an arduous task. Styling decisions were given later than promised deadlines and caused component tooling to be kicked-off late. Unanticipated by the body engineering groups was the studio request for milled surfaces after each of the checkpoints (four remained), thus generating higher costs and causing many suppliers to miss their respective tooling kick-off target date.

5.2.4 Objects and Artifacts

The team attended numerous meetings and the medium used for capturing the evolving design and the impacts to the system was the 'digital buck'. The digital buck is a globally networked computer data storage location. The location can be partitioned and protected with various levels of access. This means that the digital buck allows the subsystems to be modified based on the

input and direction of the team. The team members responsible for the respective subsystems had access to change only their subsystem. These changes once completed, were reviewed at the meetings to determine any interference conditions and assembly issues arising from the new design. All the iterations of each respective subsystem was captured and stored in this computer database. This memory was invaluable to understand 'acceptable' conditions and also created recorded history of the safety canopy design and the subsystems.

5.2.5 Ends/Results

The inflator position and location were ultimately frozen. As a result the sheet metal, which was originally a carry-over design, evolved to two existing designs until finally becoming an entirely new stamped header for this program. The rear hard trim garnish also became a new part due to the inflator cross-car packaging.

The headliners were modified in other areas not anticipated (e.g. coat hooks, C-pillar hard trim interface) and additional content was added due to the location of the canopy system sheet metal/rear garnish attachment scheme. To meet the feasibility checkpoint and kick-off long lead production tooling, designs were frozen from the other supporting groups of sheet metal, air canopy curtain, and hard trim. Out of the three, the sheet metal and safety canopy carried more influence due to the safety regulations that these subsystems were required to perform (e.g. roof crush for sheet metal, rollover deployment for the canopy). If these subsystems did not pass the federal requirements for safety, the vehicle was not saleable and could not be produced. Unfortunately, due to these fixed designs and late information from the packaging group, clearances to the headspace were not met to program intent for the headliner. The headliner, which camouflaged the gadgetry and unsightly components underneath it, was unable to change without impacting the frozen subsystem designs. For instance, reducing the dimensions of the safety canopy packaged behind the headliner would possibly provide the headliner a little offset in meeting the headroom clearance requirement, however the safety canopy would then be unable to meet its functional requirements. Thus, the headliner system required a deviation to the headspace requirements in order to kick-off tools to support the production deadline.

5.3 The Third Case – "Corporate Strategy – Overhead Consoles"

5.3.1 Background: What is the Overhead Console?

The overhead console strategy is based on the concept that if there is a part that is commonly used on every vehicle, it can be designed to be universal to all programs. This strategy was implemented to reduce overall part complexity and as a result created cost avoidances. This strategy encompasses other components within the vehicle, however this case study involves the implementation of the strategy with the overhead console.

The overhead console attaches to the headliner that is located to the roof within the vicinity of the rear view mirror (see Figure 8). Typically the overhead console contains some type of lighting feature (map lamps), storage bins (sun glass bin, garage door opener), ticket clips, conversation mirrors, and climate controls. From past designs, the proposed corporate overhead console, would attach to the roof of the vehicle, via a bracket and sandwich to the headliner system. This location was feasible, however the actual 'footprint' of the console had to be determined, along with the final designed surfaces.

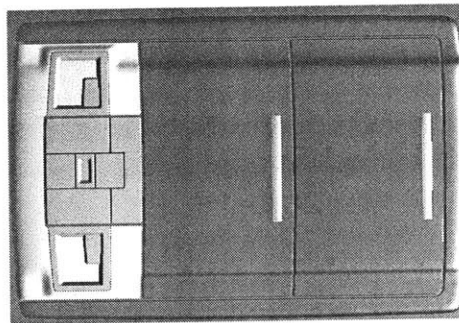


Figure 8 –Illustration of an Overhead Console

This corporate console based on the SCT direction would contain the following features: map lighting, sunglass storage bin and a conversation mirror (depending on the convenience package offered). This console was designed to be either part of the assembly of the headliner, or end item installed (in the assembly plant).

5.3.2 Novelty Encountered in the Corporate Overhead Console System

The supplier finally sourced for the overhead console part was the same supplier of the headliner system. This made the headliner to overhead console interface easier to manage since this improved both group's communication system and delivery of performance requirements. Accordingly, this same supplier was experienced with the company's product development cycle, and intrinsically familiar with Program C's nuances, since they had the headliner system on the preceding program.

The sheet metal of the roof, were assumed by program direction to remain unaffected by the new overhead console. The headliner system was new in order to accommodate the corporate overhead console system. These assumptions were created from past knowledge and experience with the overhead console systems. Since the overhead console design was not defined, novelty was created. The actual size, shape and location, was not known. Thus, the existing boundaries that were managed in the past were non-existent with the corporate overhead console design. New boundaries were created with the interface of the SCT group to the Program C team. The team selected for this task developed a new process via the use of the 'SWAT' meetings to reconcile the novelty. Additional resources were pulled to resolve this novelty and a principle actor was identified that aided to prioritize the competing requests that eventually resulted in the final overhead console design.

5.3.3 Relationship with Other Systems

From the interviewees, it was indicated that no design was available at the final design checkpoint. This caused great concern to Program C since from a historical aspect of this timeframe, a design would have been finalized and tooling for the part begun. The SCT group not having the infrastructure to create a feasible design leveraged the five suppliers that were bidding on this opportunity to assist in the design development. This process, though productive was time consuming. Each week all the suppliers were tasked to review a specific area, and based on the wide range of existing vehicle configurations, were to develop the most optimum section. With these meetings a final footprint of the console design was established, however no

supplier for the sub-components of the system were sourced during this period (switches, bulbs, mirrors).

To further complicate the problem, the 'design' developed by the SCT group was announced as not "design approved" from component styling, the studio. The entire class A surface was required to be redesigned. The supplier that was eventually sourced designed the final class A surface of the console, however the sub-supplier and the respective designs of these components still remained unselected.

Additionally, other components that were assumed to be flexible were constrained by other SCT groups. For example, the switch orientation assumed by the overhead console SCT group was different from the orientation developed and directed by the switch SCT group. The supplier of the switch later confirmed that the orientation of the connector of the switch provided by the switch SCT group was infeasible. This generated an influx of design iterations that may have been circumvented if the final corporate switch design was properly assessed to performance and feasibility requirements. This indicates that the corporate switch design was underdeveloped and not ready to be communicated to other groups.

While vehicle styling was occurring, surface appearance development for the sub-components was also performed. Numerous changes were given that were not anticipated even by the overhead SCT group. For example, the following changes were modified on the overhead console: removal of bezel between storage bin doors, speculation of theater lighting, change of shape and size of overhead console footprint, lighting and switches. Styling made appearance decisions (which affected the design) that were later than promised deadlines. Component prototype tooling was eventually allocated and used for these subcomponents due to the perceived 'high risk'. The risks identified came from the fluid evolution of the surfaces, and potential omission of a performance feature that would be too costly if put later on the production tooling. Also unanticipated by the Program C team was the studio request for milled surfaces after surface transfer, that resulted in additional surface changes that caused many suppliers to miss their respective tooling kick-off target date.

5.3.4 Objects and Artifacts

There was only one documented meeting that all parties attended to develop the overhead console. This was a weekly 2-hour SCT meeting. Computer renderings of specific sections provided by the five suppliers were reviewed and from these proposals an optimal design was determined based on these reviews. During the informal 'swat' team meetings that occurred later by Program C's team (to incorporate this console), the only medium utilized was the 'digital buck'. The digital buck allowed the designers to show how the engineering direction changed the design. From the series of the designs that were developed, any of the participants could access the design to determine the impact to other components. If a subsequent design was infeasible, the team was able to fall back and analyze the prior design. This tool was especially critical due to the lost time Program C team had to successfully incorporate this overhead console system.

5.3.5 Ends/Results

The new overhead console system has been designed, and will be used on Program C. Program C has no contingency plans thus the incorporation of this design needs to be successful if it is to be used across future platforms. Time will tell. The headliner supplier from Program C ultimately received the business for the corporate overhead console system. This proved to be fortuitous since this allowed improved communication amongst the headliner and overhead console systems. This program required prototype tooling since the subcomponents of the corporate overhead console were undefined and not sourced (by the SCT overhead console group). The justification for this tooling was to avoid costly, permanent errors in the production tools. Unhappily, since these costs were unanticipated by all, Program C had to absorb the funding for the prototype tooling for these subcomponents.

None of the body engineering groups (sheet metal, headliner system) constrained the corporate overhead console design. However the SCT groups for the overhead console and switches, along with the component studio styling of the subcomponents carried great influence on the evolution of the overhead console design. These groups did not have a mandatory requirement that would dictate the shape of the design (e.g. safety regulations). However, once the resolution of the connector orientation of the switch was satisfactorily resolved, the primary group that drove the design direction (and created the novelty) for the overhead console was the component studio styling. As a result, the overhead console design changed capriciously based on the input and influences of this group (see section 5.3.3), until a final design direction was determined.

As anticipated the headliners were modified in the area required for the new overhead system design. The overall console design and content has been finalized however, the final approval of the subcomponents design is still in progress. Although this appears behind the regular timing of a program, Program C encountered the novelty and its effects by reconciling the issues successfully. To mitigate the risk of neglecting a criticality, the program approved prototype funding for the overhead console's sub-component parts. This decision was deemed valid due to the nature of these sub-components being common to all future programs.

5.4 The Fourth Case – "Rear Glass and Sheet Metal –Late Change for the Upper C-Pillar Hard Trim"

5.4.1 Background: What is the Upper C-Pillar Hard Trim?

As mentioned in the safety canopy case study, the C-pillar is a hard trim plastic extruded part that covers the sheet metal. The location of the C-pillar part is behind the second row seating. The C-pillar typically has an upper part that interfaces with the headliner, and a lower trim part that attaches to a scuff plate. The upper C-pillar must accommodate for the air canopy package, wiring, and perchance climate control ducting to package behind it (as seen in Figure 7, from case 2).

5.4.2 Novelty Encountered in the Upper C-Pillar Trim

The interior and exterior were all new parts for Program N. However, due to the decision to modify the angle of the rear glass surface (to flatten the rear exterior of the vehicle, thereby improving the overall appearance), this generated changes to the sheet metal. To summarize, anything rearward of the upper B-pillar was required to change in order to mimic the exterior

changes. This caused the upper C-pillar, the headliner, the air curtain system and the package tray to change respective designs. These changes were made to improve the exterior appearance of the vehicle, and make it more attractive to consumers.

The changes approved by the program were well beyond the magnitude and timing of Program N. However, Program N believed without making these alterations the company would risk the loss of potentially new markets, loyal repeat customers, and degradation of the vehicle image that would result in lost revenue. As a result, the novelty was induced by the newly designed sheet metal, and rear glass surfaces. These location changes from the outside caused the interior to also change its locations, sizes, and shapes to the new components and required relational boundaries amongst all the supporting subsystems. The existing knowledge and process infrastructure had the capacity to manage this change.

The interior was broken up among various suppliers, however one supplier had responsibility for the headliners, the overhead consoles, the package tray and all the hard trim. Since all these suppliers were sourced on the proceeding program, this provided existing knowledge and history of the parts themselves, the part's relation to other components. Additionally these suppliers were also experienced with this automotive manufacturer's product development cycle, the process, the key participants, and the nuances associated with Program N.

5.4.3 Relationship with Other Systems

Being notified informally via email during the QP build event, the suppliers impacted by this change were able to prepare for this issue. This allowed the suppliers to consider the type of options available, and to prepare resources for the expected design change. The engineer provided the change description, the exact location of the change, the components impacted, the date of issue resolution, and the subsequent build events supported by the new design within a written memo called a 'Spec Tender'. For the supplier, this was the formal document that initiated development and re-design of the affected parts.

During investigations into the redesign of the interior systems, it was identified that the exterior changed caused the location, attachment scheme, and the overall performance of the safety canopy to be altered. The safety canopy had to be shifted downward to align with the flattening of the rear glass shape, and attachment scheme to the changed sheet metal. Since government and corporate level requirements to ensure compliance to safety standards regulate the safety canopy, this system had the highest priority to mature a feasible design. The safety canopy supplier defined a system that extended further forward, and had greater coverage. Due to the interdependency of the other subsystem parts to the safety canopy, the upper C-pillar and the headliner all had to adjust and accommodate for this new canopy design. The headliner, and upper C-pillar modified their respective designs and assessed part feasibility. The resolution of the safety canopy, package, and the upper C-pillar designs occurred after approximately 3 months of discussions amongst the various departments (headliners, hard trim, sheet metal, etc;).

All surface changes had to be reassessed for feasibility to performance, part manufacturability and appearance approval. Ongoing surface appearance development with vehicle styling was not a difficult assignment. As a contrast to the prior cases, the input from the Studio group was supportive in refining the parts themselves and did not require drastic surface modifications that

may have significantly affected the physical boundary conditions between mating components, and/or the reassessment of the manufacturability of a part (changing radii, draft angles, etc;). This studio also did not require milled back surfaces after the design changes. By omitting this 'requirement' Program N avoided allocation of additional timing and resources for this exercise. This indicates a high level of understanding and trust between the studio, the supplier, and the body engineering groups not otherwise seen in the first 3 case studies.

5.4.4 Objects/Artifacts

In all the prior cases the program direction letter (PDL) was used to begin design work on the systems affected, it is interesting to note the usage of the 'Tender Spec' artifact. This written document was similar to a PDL, however it provided additional concise information to the components that were changing. It answered the 5 W's: who, what, when, where, and why, and most critically how. This provided the supplier with a summary of the change required and how it was supposed to be managed. To contrast, while the program management group wrote the PDL (in the first 3 cases discussed), the engineering group wrote the Tender Spec. It appears that through this process, the engineering group for this automotive manufacturer maintains more control, and empowerment over its parts compared to the other cases reviewed.

Other tools utilized by this manufacturer and its supporting infrastructure was the use of Communication sheets, the Project Development Records shortened to the acronym of PDR, and XL notes. Communication sheets from the beginning of the design development allowed all members to communicate any issues with the design to the various departments within the OEM and the responsible supplier. These sheets, written by the supplier became especially important due to the cross-continental responsibilities and the importance of communication of the problems encountered, the additional assignments, and finally the resolution. A Communication sheet example showing the scope, and the type of details written are included within the Appendix.

PDR's were created to specifically address build related concerns. Anyone within the OEM having a concern could originate the PDR, however the supplier of the system was typically responsible for the generation of the PDR. The PDR is visually focused and has many pictures, as seen in the example in the Appendix. XL notes were created once the part was ready for release. This document (also visually focused) contained the history of the changes, the fit and finish sections and an illustration of the part to be released (with the specific changes).

During the meetings, the essential tool that resolved the novelty was a computer attached to a plasma screen that was viewable by all participants. Akin to the 'digital buck' mentioned in the prior cases, the 'driver' (person operating the computer) would access the program that stored the current 3-dimensional designs and present the problematic areas. These computer sections allowed all the participants to understand the location, the magnitude of the problem and the subsequent ramifications to other subsystems. Design changes for the parts once complete are uploaded into the computer program and reviewed at meetings to determine any interference conditions and assembly issues arising from the new design.

5.4.5 Ends/Results

So far the outcome is optimistic. Entirely different designs and tooling have been invested and created to address the appearance issue. All the subsystems, including the upper C-pillar were all frozen within a period of approximately 2 months from the Spec Tender. The ultimate interior design required a newly designed upper C-pillar, modified headliner (to interface to the C-pillar) and the safety canopy.

Program N decided to take a risk and modified a significant amount of architecture to the vehicle. The portion of the vehicle changing was assessed and deemed manageable to contain within the launch schedule of this program (9 months later than the originally scheduled launch date). However, any mistakes identified at this later stage, may potentially cause the vehicle to postpone its launch even longer due to non-compliance to government requirements (e.g. OEM cannot sell vehicle N if it fails to meet safety regulation standards). The next phase, RP will have ~ 100 saleable vehicles built and will be the true indicator whether the team captured all the critical requirements relevant for the vehicle's performance.

5.5 The Fifth Case – "Tweeter Design"

5.5.1 Background: What is the Tweeter?

The tweeter discussed in this case study is the speaker on the A-pillar trim situated in the vicinity of the instrument panel. The A-pillar trim is an upper hard plastic extruded part that is located on the sheet metal before the front door openings. The A-pillar interfaces with the instrument panel, and the headliner interior trim systems. Depending on the options the consumer requests, this A-pillar must package the following systems behind the trim: the safety canopy, the wiring, and the drain tubes (for moon roof vehicles). The figure below shows the location and the parts discussed in this case study.



Figure 9 –Illustration and Location of 2002 Nissan Altima Tweeter and Associated Parts

5.5.2 Novelty Encountered in the Upper C-Pillar Trim

Styling wanted the tweeter design to have a flush appearance with respect to the A-pillar part and thus modified the tweeter design. This created a 'no build condition' from installation and assembly issues that had been identified on a prior program. The problems centered on the installation, and the installation sequence of the wiring harness, the drain tubes and the safety canopy behind the A-pillar trim. To maintain this flush appearance four proposals were presented, and the optimum design was selected. This design proposal required the tweeter design to nest the tweeter within the A-pillar trim and modify its attachment scheme to the sheet metal (originally a bracket) and the body harness attachment points to the tweeter. This caused the A-pillar, the wiring harness, and the sheet metal to change respective designs. These changes were made to resolve the no build condition, improve the appearance of the part (eliminating gaps), and the retention of the tweeter.

Later, this novelty was encountered again during the beginning of the final phase (Stage 3). Final designs were established and tools were being ready to be kicked off. The design-engineering group informed manufacturing that the proposal reviewed and agreed upon during Stage 1 was infeasible. The infeasibility was created due to subsequent styling changes that limited the packaging space behind the A-pillar. The team (electrical, interior, manufacturing) developed another matrix of options and a final design was chosen, and implemented.

The novelty created by new tweeter design was containable within the timing of Program T. Program T's team understood the necessity to solve this issue otherwise without resolution would lead to a no build scenario. Novelty took the shape of spatial, dimensions, and attachment changes for the interior trim, electrical and sheet metal components. These changes were required due to the relational boundaries amongst all the supporting subsystems. The team with its existing knowledge and process infrastructure had the capacity to facilitate resolution of this predicament.

As a contrast to the other cases seen within this paper, OEM 3 had a core team that worked exclusively on forward model programs. The core team members worked only on new program designs and handed responsibility over to manufacturing during the first non-saleable build event of the vehicle. A large familiarity was already established among the team members since the team members already knew one another, additionally existing knowledge and expertise was created due to the specific functionality of the team to address early design development issues. These team members were extremely experienced with the process, and the key participants associated with Program T.

5.5.3 Relationship with Other Systems

The team members were notified via email to prepare for a discussion of this issue at the next scheduled meeting, the kobeya. Additional information was communicated either verbally or through email in preparation for the meeting. The information imparted included the description of the change, the potential location being affected, and the components in question.

The issue was discovered in the first stage, during the drawing reviews. The picture identified an installation problem when the tweeter was installed to the A-pillar. Four options were identified using the worst assembly configuration involving the tweeter; the safety canopy, the wiring

harness and the moon roof drain tubes. The problems centered on the tweeter attachment to sheet metal and the actual sequence of the tweeter installation with respect to the safety canopy drain tubes and electrical wiring. The safety canopy design and the moon roof drain tubes were not changed due to safety and functional requirements of these respective systems. Maintaining the safety canopy standards for this system ensured compliance to governmental and regulatory requirements. For the moon roof drain tubes the system required a sloping surface with a specified clearance to allow the movement of fluids, in order to permit the system to meet its functional requirements. Since these two parts along with the wiring harness had to package behind the A-pillar trim it became extremely important to understand the limitations of each of these subsystems in order to develop an optimum design.

All part changes required design engineering to reassess feasibility to performance, part manufacturability and styling approval. These subsystems modified their designs and again refined them in Stage 3, based on the input from design engineering. This input was based on ongoing surface development of the A-pillar trim part. The changes requested by styling caused the original proposal to become infeasible to resolve the build installation problem. The team refined the original proposal by modifying the attachment methods of the A-pillar, the tweeter and installation sequence. The final resolution of the tweeter design, and the changes to the interior, electrical and sheet metal systems occurred after approximately a total of six months of discussions in the kobeya and the obeya meetings (covered time in Stage 1 and 3).

5.5.4 Objects/Artifacts

This OEM used a 'Spec System' that formally identified to the team members that changes to a specific part. There was no formal document to organize the direction of Program T. Instead verbal or email from other team members caused the program to change course. Specifics similarly were answered in the 4W's: who, what, when, where, and but the 2 H's how often and how many. This information provided the team members with the particulars of the change required. How this change was supposed to be managed was to be determined by the team itself during the kobeya.

Drawings of the components affected, along with informally hand drawn sketches were the primary means for the creation of these design proposals. OEM 3 in contrast to the other OEM's studied in the prior case studies, did not utilize a CAD tool during the kobeya meeting. Decision Matrices listing the various proposals was created and reviewed by the team to decide on the best option. For this issue this option matrix was developed with four proposals. The kobeya team created part mock-ups of these proposals to choose the best solution. Mock-ups were again utilized in Stage 3 to refine the design of the proposal.

If a problem was identified that was not discovered during the prior design review event, a Design Investigation Request (DIR) was initiated when a potential resolution was developed. The DIR shown in the appendix is partitioned into three columns. Manufacturing group with the proposal sketched populates the first segment of this document, the second column is completed by the Design leader that provides a quick assessment of the proposed design (turnaround 1-2 days). The last section is the formal assessment from the Design engineering group that is returned within two weeks, back to Manufacturing.

A3's similar to the PDR's seen in the Case 4, were used to communicate status, omission of a requirement, an emerging issue, or a summary of the problem/event. The A3's from the beginning of the design development, allowed all members to communicate any issues with the design to the various departments within the OEM. The manufacturing and/or the design team leader were the primary parties responsible for generating the Decision Matrix, and A3's. The A3 is visually focused and contains pictures, and graphs as seen in the example in the Appendix. Colors and symbols are used to identify the status of the critical issues.

For example for a 'closed' issue a circle symbol was used; for a 'proved out' proposal a triangle inside a circle; if it is a 'feasible' proposal a triangle symbol is shown; a 'feasible proposal with risk' was represented by a triangle with 'X' inside, and the bad news was identified with just an 'X'. This document represents a snapshot of the status of the interior trim system. The simplicity of the A3 or even the more formal and larger A4 is that it presents the status of the inputs of other groups that the core team is interfacing with to resolve the interior system problems in a 1-page document!

During the meetings, the tool that resolved the novelty was a sketch board that allowed the team members to develop a proposal. These sketches and any notes were printed out and given to the team members. Computer sections were not used or needed by the participants to understand the location, the magnitude of the problem and the subsequent ramifications to other subsystems. The team members were not only the experts in their respective area but the final decision makers. This seems to indicate that although computer renderings were not employed it was evidently not required to resolve the novelty encountered in this case.

5.5.5 Ends/Results

Styling changed the design in Stage 3 causing the system to have the original problem of the 'no build' assembly condition. This was created due to changing the surface of the A-pillar design that created less area behind the A-pillar. The less amount of area did not allow all the systems (e.g. safety canopy, moon roof drain tubes, and wiring harness) to successfully package behind the trim, or allow the tweeter to be installed correctly without risking quality and functional performance requirements. Through modifications of: the tweeter becoming a sub-installed part (a component of the A-pillar) the assembly installation sequence, and the attachment scheme of the wiring harness connectors the design developed resolved the installation problem. All the subsystems, including the A-pillar were all frozen within a period of approximately two months. The ultimate interior design required a modified A-pillar, wiring harness, sheet metal attachment points, and assembly installation sequence.

6.0 DISCUSSION

6.1 Satellite Dish Radio Antenna System

6.1.1 Technological Familiarity Matrix

Using the Familiarity matrix, for this case, the company's current 'base market' is the overhead system. The 'base market' could signify anytime of market, however the author has scoped the 'base market' to mean the overhead system. The overhead system includes the headliners, overhead consoles and all the parts attached to these subsystems (e.g. wiring, sun visors, coat hooks). The company's "base technologies" were again, seen to include it's internally developed infrastructure. Figure 10 shows the location of the case on the Familiarity Matrix.

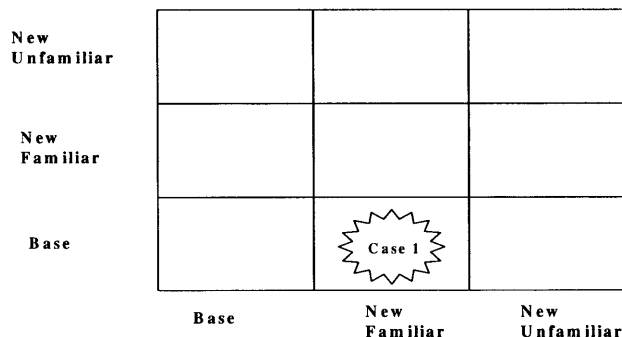


Figure 10 –Familiarity Matrix for Case 1

Based on both technical and business experience in this industry, Case 2 has been positioned on the y-axis, in the 'base' market, in the 'new, familiar' for the technology on the y-axis. The base market of the overhead system remained the same. The technology utilized involved "new but somewhat familiar" technology from the company's perspective. The SDARS feature used technology known and understood by the company. Although the SDARS feature was not introduced before to Program A or B, due to the familiarity with the amount of changes associated with electrical systems, Program B was able to successfully anticipate the impact of the changes involved to incorporate the SDARS feature.

The underlying reason why the SDARS was introduced to the program was to provide the same level of content and features as its competitors. The novelty introduced in this case augmented a current product. The important information gained from this matrix is that the skills and capacity required for this change existed within the company's current configuration, and the current organization's infrastructure provided support to successfully incorporate this novelty.

6.1.2 Objects/Artifacts

There was only one forum that allowed the necessary participants to explore options for the SDARS addition. This forum was the bi-weekly Packaging meeting that was chaired by the Packaging group. The meeting room was relatively small thus spacing was limited to core participants impacted by the novelty. At most, twelve people occupied the room during the meetings. Due to the limited number of participants, this created an informal feel that encouraged interaction.

This action meeting, started with a set agenda, however due to the constructive discussions involved during the meeting the agenda was not adhered. Meeting minutes although infrequent became important documentation of the latest SDARS design. For participants that could not attend the meetings, it provided status of the latest developments, and areas of impact.

The purpose of the meeting, involved resolving interface problems with different systems with the SDARS introduction. The key participants involved contributed information regarding fixed constraints to their respective subsystems (fixed locations, compression requirements, etc) that aided in determining the final location, and attachment methods that were viable for the SDARS. This meeting was considered extremely valuable to the participants since it was the only person-to-person meeting that allowed all the parties to jointly work on the solution. Although e-mails and phone dialogue supported quick communication of latest designs, it was not the central event that created the interactive environment for resolving the SDARS novelty. The novelty was managed effectively with a smaller sized group of participants, since greater interaction was encouraged, leading to communication and the transformation of knowledge into solutions.

The utilization of the digital buck and paper sections of computer part drawings for these discussions provided the common language for the engineers to communicate and understand. The objects employed during these meetings, created an approach that that enabled resolution for any given subsystem.

It was noted with frustration from the participants interviewed that this meeting did not align to the agenda. This shows a positive aspect of the meeting that it generates interaction among various department boundaries of systems, however; it becomes extremely difficult for key participants to support the meeting if it runs over the schedule time (key participants roughly have 5 –6 average meetings/day and becomes harder to manage time and other demands). Since this meeting occurred bi-weekly, additional time scheduled is recommended to continue the dialogue and resolution for this type of novelty.

6.1.3 Management of Novelty –Dynamics

The novelty encountered by the SDARS introduction would be resolved quickly as it was the program's critical assumption. This assumption was based on the familiarity of the program with the types of novelty generated from the electrical subsystem. Program B assumed that the information gained from these prior events and interactions was adequate to manage the changes involved with the SDARS design. It was predicted that the same situations that occurred during prior design iterations with the electrical systems would have a similarly outcome with this situation. The prediction proved to be correct. The novelty with the SDARS feature was unique, however similar enough for the program to manage and resolve the novelty. It is also noted that relationships with the subsystem suppliers and other key participants remained unchanged and existing resources were sufficient to reconcile the novelty.

Using the 3 T Framework and the Hierarchy of Novelty, the program made the assumption that the novelty, from the SDARS was seen as a Level 1, expected novelty. This type of novelty required modifications from the actors and participants to transfer the knowledge from the syntactic boundaries. These boundaries existed between the various groups of subsystems (refer

again to Figure X). The electrical, sheet metal, hard trim and headliner subsystems needed to reconcile the potential ramification of the SDARS introduction on their respective subsystems. The knowledge of the SDARS feature, the requirements and constraints had to be identified. Additionally, and equally as important, the subsystem requirements and constraints needed to be given.

The skill set, and the resources utilized were assumed to be adequate and capable of addressing this novelty. The team understood the syntax of the program assumptions and assumed based on 'past history' that this electrical commodity would have the same predictable needs and thus, knew the impact on the other subsequent systems outside of the boundaries. The rather uneventful incorporation the SDARS feature indicates the expected novelty, of Level 1. The subsystems when facing the novelty altered their respective designs to accommodate the feature. The organization's capability existing within the current system, was sufficient to support the SDARS late addition to the program, since its reliance on the current process and infrastructure had some existing knowledge when translated addressed the novelty and resulted in the successful incorporation of the feature.

The SDARS novelty was managed with the bi-weekly Package meeting. This meeting although small in size, created an informal environment that encouraged interaction among the participants. The digital buck, the central object used, provided a method of communicating in a way that could be understood by the interfacing subsystems. A common understanding was established, which allowed the participants to transfer the knowledge provided from constraints and requirements, and identify the problems seen at the interfacing subsystems. This tool, allowed all participants to comprehend and understand the impact of the novelty in respect to their system's package space, surface and functionality. Any interference conditions seen at the physical boundaries of the mating subsystems in the digital buck were addressed in subsequent Package meetings to solicit advice or suggestions to create an optimum solution. The meetings and the objects utilized allowed the knowledge to be resolved for any given subsystem.

SDARS was incorporated in Program B prior to the tooling kick-off. The fortuitous assessment the impact of the situation and the impact to the program made the program assumptions valid. The assumption to incorporate the SDARS feature once directed in the program provided the concrete decision that the program was invested in this decision. Once this decision was made, authority was permitted to assess the novelty (impact to other subsystems), and the team determined the best approach to tackle the issue (e.g. process modifications and/or resource management). The program's acceptance of the SDARS feature generated specific requirements due to this late addition. Within these requirements, the program also had to avoid creating too much change to the already designed subsystems (that met styling, and performance approvals). Based on the requirements, the impacting subsystems were identified and the final location determined. The semantic boundary that the program had was able to manage the knowledge translation to resolve the novelty. By gaining consensus with all impacted parties, minor modifications to these existing subsystems allowed the incorporation of the SDARS feature into Program B. The current organizational infrastructure supported, and helped foster further enrichment when encountering this type of novelty, thus strengthening the organization's capability.

6.2 Safety Canopy System

6.2.1 Technological Familiarity Matrix

The figure below shows the company's familiarity with this technology and its core market. The company's current 'base market' is developing a variety of overhead systems for consumers. This company's 'base technologies' were seen to include its internally developed infrastructure.

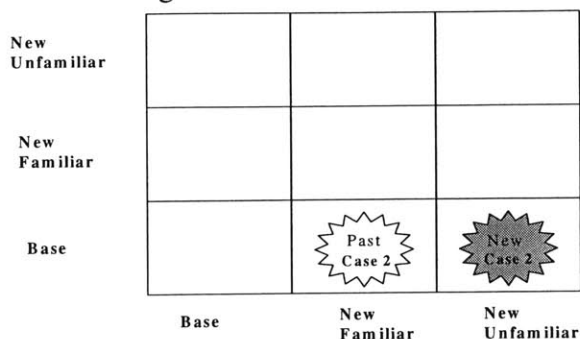


Figure 11 –Familiarity Matrix for Case 2

The author, having both technical and business experience in this industry, positioned the past (Past, Case 1) and new (New, Case 1) on the technology and market familiarity axes. Both technologies however, targeted the same, base market. In terms of technologies acquired on the x-axis, both involved "new but somewhat familiar" or "new and unfamiliar" technologies from the company's perspective. The Past, Case 1 involved technology known and understood by the company produced successfully on Program A (the 'mother' of Program B). The New, Case 1 introduced novelty to Program B with the new functionality of the safety canopy, and establishing new relationships with a new safety canopy supplier.

The goal of novelty introduced in Case 2 was of filling a product and technology gap. The information derived from this matrix is that the skills and capacity required is different from the current infrastructure due to increased novelty.

6.2.2 Objects/Artifacts

There were many meetings and the information evolved from the first morning meeting to something sometimes completely different at the end of the day. A summary is provided to understand the number of meetings required, the purpose of the meetings, the participants involved, the frequency, the location and the tools employed to resolve the novelty encountered during the period of the safety canopy development (Table 3).

Meeting Type	Location/ Chaired	Frequency	Function	Tools/Artifacts	Actions
Air Curtain Feasibility	Ford room/ Packaging	Daily, Morning 1st	Package Air Curtain	No agenda and/or meeting minutes Paper sections, limited digital buck	Curtains – presenting Interiors, Suppliers -listening
Studio Timing Review	Ford Studio/ Studio	Daily, Morning 2nd	Status of interior and exterior surfaces to management	Agenda sent to select individuals No meeting minutes Reviewed boards, and clayed vehicles/components	Studio – presenting Interiors, Suppliers, Program Management–listening
Sheet Metal Feasibility	Ford, desk/ Sheet Metal	Daily, Morning 3rd	Determine feasible locations for trim attachments	No agenda and/or meeting minutes Surfaces reviewed on computer	Sheet Metal – presenting Interiors, Suppliers – participating
Program Management Team (PMT) Open Issues	Ford room/ PMT	Daily, Afternoon 4th	Update PMT leader	No agenda and/or meeting minutes	PMT – presenting Interiors, Suppliers -listening
Studio Feasibility Review	Ford Studio/ Studio or Supplier Designer	T, Th, Morning	Review revised interior surface sections	No meeting minutes Hard copy agenda at meeting only Surfaces reviewed on computer	Studio, Supplier– presenting Interiors, Program Management, Chief Engineer – listening
Interior Program Attribute Team (PAT)	Ford room/ Packaging	Daily, Afternoon 5th	Resolve packaging issues between upper and lower trim	Meeting minutes Surfaces reviewed on computer	Packaging –presenting Interiors, Suppliers - listening
Sheet Metal Master Sections	Ford room/ Sheet Metal	M, W, and Th Afternoon	Review and sign-off on sheet metal master sections	No agenda and/or meeting minutes Open Issues Matrix given at meeting	Sheet Metal – presenting Interiors, Suppliers -listening
Packaging	Ford room/ Packaging	T Afternoon	Resolve interference conditions throughout vehicle	Agenda, and meeting minutes sent out Sections reviewed on computer	Sheet Metal – presenting Interiors, Suppliers -participating

Table 3 –Case 2 Types of Cross-Functional Meetings

The meetings shown above can be classified into two types of meetings: informational meetings and action meetings. The informational meetings were done to review the work accomplished, and occurred to track the program's development to the programs milestone deliverables. These meetings involved any number of participants, and the communication was mostly a one-way process. These highly structured meetings had one or more people presenting, and then allowed opportunities from the attendees to follow-up with questions and/or comments. The person that sent out the agenda indirectly became the moderator for these proceedings. The style of these meetings was more authoritative, and the emphasis of the meetings was on content changes.

The action meetings involved a more interactive discussion in resolving complex tasks and/or decisions. The style of the meetings was more participative in nature, and the number of attendees was less (12 or fewer). Participants attending were those responsible for the subsystems and could contribute to resolving the novelty. The emphasis of these meetings was on interaction and problem solving. Meetings were standing (regular), topical (specific to one subject), presentation (structured, to inform), and conference (structured, participants contribute following fixed agenda) meeting types.

The majority of the meetings were action meetings, centered on resolving interface problems with different systems. The information and the different participants involved allowed multiple systems to develop concurrently based on introduction of different levels of novelty introduced from the safety canopy system. Meetings that the participants considered 'valuable' for the

design of the safety canopy system were the Air Curtain, Sheet Metal Feasibility, Interior PAT' and Packaging discussions. The novelty appeared to be more effectively managed in these meetings due to the smaller group size, the equity, and need of the participants to resolve the issues. The objects utilized the digital buck; paper sections of computer part drawings for these discussions and also provided a medium for the engineers to communicate in a common language and understanding. The meetings and the objects utilized allowed the knowledge to be resolved for any given subsystem. It was also observed that the agendas, if published prior to the meetings and managed without issue, allowed specific engineers to support topical subjects. Meeting minutes became important documentation due to the constant changes of the subsystems. If people were unable to attend these meetings, it provided status of the latest developments.

Meetings that were perceived non-value are shaded above. These meetings focused purely on timing deadlines, and updating non-participants that were far removed from the designing of the system. Meetings were not managed as effectively as the non-shaded meetings shown above, because the collective process of translating the knowledge given in these meetings did not occur. As a result, any novelty encountered in these meetings was probably not recognized. Additionally, these meetings did not create a favorable atmosphere in promoting novelty resolution. For instance, in the Studio Feasibility Review attendees did not recognize or know the other participants due to the large number of people supporting these meetings. It was also more difficult to understand direction and/or outcome of the decisions due to lack of published meeting minutes. Since these meetings dealt with a larger audience than primarily engineering groups, e.g. studio, program management, not all the information presented was understood. Commonplace terms and acronyms from one area may mean something else to another group. Attendees were intimidated in asking simple, clarification questions possibly to avoid being labeled as 'inexperienced'.

As a result, much novelty arose just in the various groups presenting their respective progress on design issues. For example, a class A surface presents different meanings for the various departments. For the supplier of the subsystem this is a surface that means, removing any surface designed line that causes surface blemishes, and meets the supplier's manufacturing constraints. For the body engineer, this is a surface that has studio approval, and can be easily installed in Program B's assembly operation. For the studio group, the class A surface is to represent perfection and resolution of any surface line problem. For the program management group, the class A surface is just the aesthetics of the part, and its status to meet program timing. Unfortunately the objects used in these meetings, to facilitate the boundaries were not very useful. Also problematic was the fact the agenda function, lacked purpose (the remainder of these meetings did not utilize an agenda). The one meeting that had an agenda; the Studio Timing Review was published but not followed. Participants would specifically support this meeting to understand the issues and status on an agenda topic. Unfortunately, sometimes the issues never were discussed due lack of focus (jumping from different topics) and poor time management.

The novelty encountered in these meetings, can be better managed with a smaller sized group of participants, since greater interaction is encouraged, and can lead to improved communication. The agenda should be utilized for all meetings, however for topics under discussion, the parties

affected should also be listed (e.g. electrical, climate control, safety). This minor change to the content of the agenda would attempt to control the number of attendees in these meetings. Reducing the number of attendees should provide an improved environment that facilitates the need for participation, inquiry, and interaction. This interaction would allow the participants a chance to identify the problematic issues, and engage in the process of transforming the knowledge given into a solution.

Another object that would assist in translating the information presented in these meetings would be the use of a standard pro forma. This pro forma would have the location, the dimensions, and the referenced computer file sections of the problematic area. This form would also contain a picture of the system in question, labeled with the parts to be discussed. This pro forma would also provide definitions of the words frequently used and their respective meanings in order to reduce misinterpretations and costly iterations. If used, this pro forma would enable all parties to understand the location, terminology, and other important features relating to the problem. This would provide a tool to improve the translation of the novelty encountered.

Lastly, it appears that the majority of all the meetings were not well managed. The topics presented in the meetings were discussed longer than anticipated. This initially appears to be a positive attribute, however, it may also indicate that the presenter may have been ill prepared, lingering and presenting inconsequential information. Adherence and repeated use of the pro forma should reduce the chances of this problem occurring and a sense of regularity for the attendees of the norms of the meetings, the process and its purpose.

More importantly this lack of time management indicates two other culprits. The first appears to be an overload of the number of topics that can be discussed during an allotted time frame. Reducing the number of issues on the weekly agenda can easily rectify this. This can be done by the meeting coordinator estimating the average amount of time required one topic discussion based from prior meetings, and experience. The second appears to be the lack of discipline of managing the actual time of the meeting. People are too polite, and the attendees at the meeting lack the power to move the discussion on. Thus, it is important to have a timekeeper. This person would be required to manage the time, and recognize that if the topic requires more dialogue, it should be tabled and rescheduled for another time. By employing this action, not only indicates the respect for other attendees' time, but also reinforces the concept of specific audiences for specific topics. Based on the agenda time, another group of participants would be arriving for the next topic of discussion. Since this agenda is published to a wider audience, there is a required need to maintain a schedule. Otherwise, non-credence is established and the meeting begins to lose its primary purpose in identifying novelties. If the meeting is perceived as non-valuable participants who can contribute to the issues at hand, will not attend. Thus, it is extremely important for specific personnel to manage the time of the meeting. The purpose in managing the time for the meeting could be anyone, however, it would ideally be the person that originated the meeting and/or the agenda.

6.2.3 Management of Novelty - Dynamics

The safety canopy design depended on the program's assumptions that issues arising from this novelty would be resolved quickly. The novelty encountered in this case, was not something seen during the lessons and experiences learned in developing Program A. The program

assumed that the information gained from that program was sufficient to manage the changes involved with Program B's safety canopy design. It was predicted that the same situations occurring on the prior program would be similarly encountered here. However, the novelty seen in Program B was uniquely different in terms of the constraints addressed, and the dynamics of developing relationships with new suppliers. Luckily, supporting groups (styling, interior trim, sheet metal, etc.) were also aligned in resources and priority to address the safety canopy changes.

Getting results was more complicated than anticipated. The team dealt with changing designs of the canopy system and committed to completing tasks never done before. Issues were pursued aggressively and resources were leveraged to reconcile impact of the canopy system evolving design to respective systems. The 'valuable' meetings did not focus on scheduled targets may have indicated the difficulty of novelty managed by the team.

Program assumptions for this novelty, were seen as a Level 1, expected novelty (from Gilbert Hierarchy of Novelty) that required modifications from the actors and participants to transform the knowledge from the semantic boundary. However, the reality of this situation was the novelty introduced with the safety canopy system was grossly underestimated and was a Level 2, latent novelty. The resources and the skill set to resolve this challenge were assumed to be available and capable of addressing this novelty. The team had the capability of understanding the syntax of the program assumptions but not the impact on the other subsequent systems outside of the boundaries. Problems encountered within the design stage provide indicators of Level 2, latent novelty. Although significant capability existed with the current system, it was not adequate to rely on the existing process and infrastructure to support the new technology.

The design cycling required time to adapt to the new content given, and develop the infrastructure for the new technology. This presented challenges since the program assumed a shorter period to acquire this novelty. The means and methods to resolve novelties with the safety canopy system took the form of daily meetings. The meetings that were smaller in size, informal were more effective for interaction and participation of participants. The primary object utilized - the digital buck, provided method of communicating with common understanding among the interfacing subsystems. Since a common knowledge was already established, it allowed the participants to translate the knowledge provided in identifying problems at the interfacing subsystems. These problems were presented as subsequent topics at these meetings and to reconcile subsystem interferences. The meetings, and the objects utilized allowed the knowledge to be resolved for any given subsystem.

However the evolution of the safety canopy design was not isolated. Any changes impacting the subsystems from other areas also impacted and changed the designs of all the subsystems. Participants recognized the latent novelty however information was so fluid that the dependencies to other systems also altered with design iterations. Figuratively speaking, like jumping rope, when one subsystem jumped, all the interfacing subsystems also had to jump too. It was also observed that no project leader, or principle actor was available or even recognized by the team to have stewarded the process and correlate the downstream impact to all relating systems (seeing the big picture). Problems arising were addressed to all participants to solicit solutions. The actors that managed these knowledge boundaries utilized tools recognized by all

participants. The most valuable tool employed by the team were the computer renderings (the digital buck) that allowed all participants to comprehend and understand the impact of the novelty in respect to their system's package space, surface and functionality. These iterations of design were captured most effectively by the usage of meeting minutes and agenda items. Meeting minutes assisted in recording of open issues for investigation and the agenda provided notification and allowed for a manner of preparation for other areas affected.

Decisions became final with little resistance towards the last checkpoint (fifth). Important assumptions provided the framework that allowed the design to follow. These concrete decisions allowed the design to acquire specific dependencies. For example, the rear garnish supplier announced the necessity to have the back glass in CAD data because it was 55 mm rearward of the previous location. This assumption was required since no early program feedback was given for the back glass location. This location was essential for the design of the rear garnish. The garnish supplier was also clearly dependant on the air curtain ramp location and design for packaging and attachment reasons. However, since no definite decisions were made to finalize the rear garnish design, the supplier took matters in their own hands and provided the sheet metal group an attachment location required for the garnish. From this decision, the architecture of the rest of the subsystems was finalized due to this dimension. Subsequently, the design was allowed to be completed with final positioning and attachment schemes for the headliner system. This semantic boundary required participants to develop a common understanding to resolve the novelty. The novelty was resolved by providing a decision that allowed the effected systems to focus on closing their respective designs. The current infrastructure and processes did not support the rigorous program timing, thus bold decisions finalized the safety canopy design, resolved and transformed the novelty seen by other affected systems.

6.3 Overhead Consoles Strategy

6.3.1 Technological Familiarity Matrix

As shown in the prior case studies, the author has graphed the company's familiarity with this technology and its core market. The company's current 'base market' is developing a variety of overhead systems for consumers. The 'base market' could signify any type of market, however the author has scoped the 'base market' to mean the overhead system. The overhead system includes the headliners, overhead consoles and all the parts attached to these subsystems (e.g. wiring, sun visors, coat hooks). This company's "base technologies" were seen to include its internally developed infrastructure. The figure below shows the location of the corporate overhead console strategy.

New Unfamiliar			Case 3
New Familiar			
Base			
	Base	New Familiar	New Unfamiliar

Figure 12 –Familiarity Matrix for Case 3

The placement of this novelty is positioned in the 'new, unfamiliar' business region on the y-axis due to the magnitude and scope of this initiative being implemented by the company particularly in the market of the overhead systems. Similarly, this case is aligned in the 'new, unfamiliar' territory on the technology x-axis since this is actually the first business endeavor for this headliner system supplier being awarded an overhead console system. Case 3 introduced novelty to Program C with the new content, scope and functionality of the common overhead console system, and established the new capability of the new overhead console supplier.

The goal of novelty introduced in Case 3 was to create a common design of a system that was utilized across all platforms. This could be perceived as a technology gap; however it is a corporate strategy. From this matrix, the following information can be derived the skills and capacity required is radically different from the current infrastructure.

6.3.2 Objects/Artifacts

Only two meetings had been confirmed to occur that drove and eventually resolved the common overhead console design. Table 4, provides a summary, the purpose of the meetings, the participants involved, the frequency, the location and the tools employed to resolve the novelty encountered during the development of the overhead console system.

Meeting Type	Location/ Chaired	Frequency	Function	Tools/Artifacts	Actions
SCT Overhead Console	Ford room/ SCT group	Weekly, Wednesdays	Design Feasibility of Common Overhead Console	Agenda, no meeting minutes Paper sections	Overhead Console Suppliers – presenting Interior, SCT –listening
'SWAT'	Ford desk/ Interior or Supplier	Every evening	Develop A-surfaces for Common Overhead Console	No agenda and/or meeting minutes Digital Buck	Overhead Console Supplier, Interior - participating

Table 4 –Case 3 Types of Cross-Functional Meetings

Both of these meetings can be classified as action meetings. As mentioned before, these meetings required participation and active discussion to resolve the complex task at hand, to develop a common design that would be used on all vehicle platforms. For example, with 12 or fewer participants, the SCT overhead group was able to partition the area of the console in manageable segments. Based on the information and experience provided by the five overhead console suppliers, an optimum design was established for each of the various sections. The SCT switch group also contributed to additional novelty that later became resolved from the input from the switch supplier. All of these participants gave invaluable information that influenced the contents and the final design of the overhead console system.

The other 'SWAT' meeting was primarily focused on the 'guts' of the overhead console system and to develop an actual design that would translate into a producible part. The team members from Program C, that were responsible for the overhead console design, affectionately dubbed the meeting as a 'SWAT' team to reference the quick, and efficient way the meeting and the participants resolved the problems encountered during the console development. The emphasis of the meetings was on interaction and problem solving, and centered on resolving interface

problems with different systems. Other participants that attended this meeting less frequently were brought in to assist in the resolution of the novelty with respect to the method of attachment (vehicle operations), and the usage (ergonomics).

The novelty encountered appeared to be more effectively managed in these meetings due to the smaller group size, the investment of the participants to resolve the issues. Objects utilized - the digital buck, and the paper sections of computer part drawings provided the instrument for which the engineers could communicate in a universal language with meanings understood by all. These objects were deemed unbiased since they were created from scientific parameters that were qualitative and not subjective by nature or influence. These meetings, and the artifacts employed allowed the communication of knowledge to resolve novelties encountered for any given subsystem. Agendas that were used in the SCT console meetings allowed specific engineers to support topical subjects. Due to the informality of the start time and end of the 'SWAT' meetings a formal agenda were not published. The topics of conversations in these meetings were a result of the issues generated through the SCT overhead console team meetings, and/or from analyses that indicated potential 'hard rock' problems.

It was interesting to note that the singular meeting to design the common overhead console was only allotted 2-hours. It was commented that the suppliers who presented in these meetings provided constructive information, however dialogue was curtailed and further elaboration was prevented due to the short amount of time allocated for these discussions. This appeared to be poor time planning and an inadequacy to truly immerse into the design details. Upon reflection, too many issues were surfaced based on the agenda topics. By either reducing the number of issues on the weekly agenda and/or increasing the time for the meeting would have solved this problem. The originator of the meeting from past experience can estimate the average amount of time required for each topic. This person would manage the time, and recognize that if the topic requires more dialogue, it should be tabled and rescheduled for the next meeting. By employing this method, indicates the proper respect for other attendees' time. Credence to the purpose and responsiveness of the meetings in providing a vehicle to drive novelty resolution is thus reinforced.

6.3.3 Management of Novelty - Dynamics

The novelty seen in this case was white space, Level 3. The program assumptions for this novelty were expected to be greater than any type of changes encountered in the past. The boundaries encountered within this case were pragmatic. The participant involved had different priorities and expectations for this console system. The group eventually developed mutual goals in order to develop the final design of the corporate overhead console system. The resources and skill set to resolve this situation went beyond the typical design changes. Other supplemental groups provided additional insight and direction for the overhead console design. For example, the input from the ergonomics group provided acceptable positions on reach zones (how the driver or passenger accesses the overhead console controls), and gave valuable information on the size and shape the controls should be designed for optimal performance (e.g. if consumer wears winter gloves, can the controls still be operated?). Since the corporate initiative was not something experienced before by the organization, the existing processes could not resolve the novelty within the current infrastructure. Hence, the SCT group involvement and more critically, the 'SWAT' team were the two forums that created a process and supporting

infrastructure to address the novelty. This was evidenced quite clearly in the 'SWAT' meetings, given that all the participants although having equal capability in their respective specialty, developed mutual priorities of attributes and requirements that were equally shared amongst the team to develop a design.

Problems that developed provide clear indicators of Level 3, white space novelty. For example, to meet the timing of Program C, the supplier selected for the overhead console strategy leveraged the signing of an early sourcing agreement by the SCT team. This document protected the supplier for all the design surfacing this supplier had completed on the corporate overhead console design. The supplier cleverly withheld these designed surfaces until the sourcing agreement was given. This ploy was done since the current processes did not resolve the novelty (in this instance establishing the selected supplier for the overhead console system) to support the delivery of a feasible, and producible system for Program C. Thus, although significant capability existed with the current system, it was not adequate to rely on the existing process and infrastructure to support the new corporate strategy.

The console design depended on SCT group's content assumptions and that a final design would be developed that could be implemented quickly onto Program C. However, the development of the content assumptions and overall footprint for the console took longer than anticipated due to no current infrastructure to support this process (and additionally, insufficient scheduled time for discussions). The novelty seen in this case was not something discovered during any experiences from other program platforms. The team, and the program realized that current processes were insufficient to manage this design challenge. Fortunately, the supporting groups (component styling, interior trim, SCT overhead, SCT switch, sheet metal, etc.) also aligned resources and priority to address the design of the common overhead console system. By establishing different processes, and mutually driving to a common goals and objectives the console was successfully designed and implemented on Program C.

The component styling group did not recognize the design and content developed by the overhead console SCT group. This came as a setback to the planned incorporation on Program C, since the SCT had invited studio counterparts to support the overhead console design. It was identified later that the SCT omitted accidentally to invite the component styling group for their concurrence on the proposal. Due to this omission and lacking the input from this group, the overhead console design for the components had to be refined to an acceptable level to gain component styling approval. Thus, component design changes required the supplier of the overhead system, and the sub-suppliers to adapt to the various changes being driver, and develop a supporting capacity and infrastructure for it. This presented challenges since the Program C was required to incorporate this common console and the design (of the sub-components) was still being finalized in designs (and even sub-supplier sourcing).

As a result the means and methods to resolve the novelty of the common console took the form of the overhead SCT and 'SWAT' meetings. These meetings were informal, smaller sized, and created a constructive environment that developed a common rapport to discuss conflicting requirements and eventually reach a point of compromise, that was mutually accepted and agreed upon to create an optimum console design. The digital buck, the primary instrument utilized created a method of communicating amongst all the groups (component styling, ergonomics,

SCT, and interfacing subsystems). A common language existed (in the form of the digital buck) that enabled the participants to translate the knowledge provided to identify problems, and then transform these problems into solutions. Problems identified were presented as subsequent topics at these meetings to reconcile subsystem interferences. The meetings, and the objects utilized allowed the knowledge to be resolved for any given subsystem.

As the rope jumped, all the subsystem components shifted and modified their respective designs to support the mutual goal of creating a common overhead system. Participants recognized the 'newness' of this initiative and understood that the design would iterate frequently. The SCT overhead members were recognized as the project leaders for development of the overhead content, however the singular actor that drove the product design creation for the console was actually the overhead console supplier. This supplier, in the beginning had nothing to distinguish itself among the other competitors for this console business opportunity. The tenacity and the perseverance in developing the class A surface design is what separated this supplier from the others, and heavily contributed in their favor for the console system sourcing decision. Since this was a new business sector for this supplier (prior only had headliner systems) the reputation and capacity of this supplier was called into question. As a result, this supplier became the principle actor that initiated the 'SWAT' meetings as a process to steward the conflicting issues, and understand the influence of these decisions to relating systems (seeing the big picture). Problems that arose were addressed to all participants to solicit solutions. Actors that managed these knowledge boundaries utilized the tool recognized by all participants. The digital buck allowed all participants to comprehend the impact of the changes with respect to their different knowledge and expertise (in a specific area, e.g. ergonomics, or a subsystem). These design iterations were managed in the 'SWAT' forum.

Approvals on subsystem designs were given, and suppliers sourced. Program direction, although it provided the authority, did not provide an infrastructure that supported the needs of this novelty. While a framework of a process was developed with the SCT meeting, the 'SWAT' meetings later refined it. Decisions mutually agreed upon, in the 'SWAT' meetings allowed the subsystem component design to be developed. This pragmatic boundary involved new participants and other groups (outside of the current process) to assist in the development of a process to resolve the novelty. The common overhead console system was resolved with the informal 'SWAT' meetings. These meetings allowed critical decisions to be created that refined the design of the console. Although the current infrastructure and processes did not support the rigorous program timing the involvement of diverse groups devoted to this design along with a primary actor filtered these inputs into a design that represented all the needs of the participants. The information was transformed by reviewing these proposals, making decisions that finalized the design of the common overhead console.

6.4 Upper C-Pillar Hard Trim

6.4.1 Technological Familiarity Matrix

Aligning this company's familiarity with this technology and its core market, the following assignment is seen, in Figure 13. The company's current 'base market' is developing an interior system environment pleasing to consumers. If the company did not change its interior overmuch, it is inferred that it remains in its base market. However, if the interior of the vehicle

is entirely redesigned (by familiar means and processes), the vehicle has the potential of attracting a different market segment, and is assigned into the "new, familiar" quadrant on the y-axis. For clarification, the interior environment defined here to indicate the hard trim, headliner, overhead console and the package tray.

This company's "base technologies" were seen to include its internally developed infrastructure to support changes. Since this unanticipated change occurred after designed parts were released and built during RP, it is reasonably assumed that this event does not occur frequently with the OEM 2, and as a result aligns on the x-axis, in the 'new, unfamiliar' region.

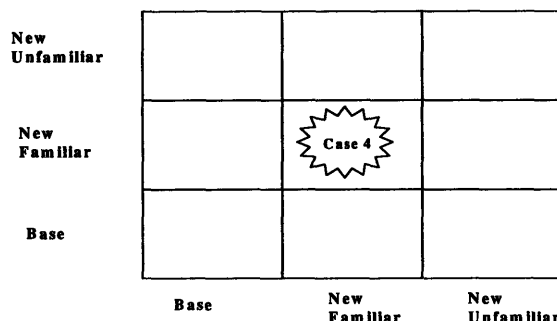


Figure 13 –Familiarity Matrix for Case 4

The introduction of this novelty was to fill a perceived gap in a product. This gap was based on customer reviews of the product, vehicle N. From this matrix it is inferred that the skills, resources and capacity required was adequate to address this kind of novelty.

6.4.2 Objects/Artifacts

Only two weekly meetings managed the issues involved with this change. These meetings were Upper Trim Feasibility Reviews that reconciled the problems associated the exterior changing. The meetings were held at the OEM 2 however only participants affected supported these meetings. No agenda announced the topics to be addressed; however the suppliers would generate and maintain List of Open Issues. This list was used to begin the discussions, and carried in new relevant topics. Additionally it provided a method to track progress, next actions, responsible parties and closure dates.

Meeting form tended to be informal, and clustered around a computer to review the projected sections. The amount of participants supporting the meetings ranged from 3 – 10 depending on the subsystem being discussed and the issue involved. Program N, to have a maximum of only 10 participants, restricted the amount of participants –any additional participants were requested politely to be excused from the discussion. This request was done since Program N believed that larger numbers of participants stifled the participatory discussions that were required within these meetings. These action meetings became the forum to resolve complicated interdependent system issues. Some striking differences about these particular standing meetings is that if a proposed direction was not mutually agreed upon by the team, the meeting would not end (think filibuster). Typically these meetings lasted approximately an hour long. However, the interviewee indicated that some meetings that began at 2 pm did not end until after 9 pm. Once decision was made, clear and specific directions were given on how the design was to change. These are two additional characteristics that make these meetings different from the other OEM's

studied –there were no mega-marathon meetings, and thus the design proposals did not evolve to specific levels until subsequent meetings.

Changes appeared to be effectively managed in these meetings due to the smaller group size, the equity and need of the participants to resolve the issues. The objects utilized - the computer renderings, the open issues list and PDR's provided a medium and a system that recorded the changes occurring. The computer sections reviewed permitted the participants to identify and relate to the issues at hand, as a result this tool was very effective in communicating and conveying problems even through difficult language barriers (Japanese, and Spanish communications). The meetings, and the objects utilized allowed the knowledge to be resolved for any given subsystem. With the use of Communication sheets and PDR (Project Development Reports) issues were communicated and documented to all parties affected.

6.4.3 Management of Novelty – Dynamics

Program N during a critical period, made the decision to change its released parts to something more aligned to the expectations of its consumer market. This careful attention to the customer wants and needs should be credited, however this issue indicates that this problem may have been circumvented early on –by having a survey clinic of styling themes and selecting the most favored design theme. In this situation, novelty was created by frozen designs, per the program's direction became 'unfrozen'. However due to a fixed timetable to launch the vehicle, the decision was made to modify the exterior rear glass of the vehicle. By changing the orientation of the rear glass, changed the look of the shape of the vehicle. This change caused the sheet metal to alter its respective part in order to provide structure and attachment for the rear glass.

As a result of these exterior architectural changes, the inside environment of the vehicle had to adapt to these new sheet metal locations, and new glass position. The safety canopy, one of the most critical systems in the interior due to its regulatory requirements, was the first to be adapted with the new exterior changes. Due to the dependency of these three systems, the upper C-pillar, the headliner and the package tray developed designs. The novelty encountered in this case, was not (it is hoped) something typically seen or experienced from past programs. The program made the assumption that novelty introduced would be managed with the capacity and the supporting infrastructure of the organization and its suppliers.

The supporting groups (styling, interior trim, sheet metal, etc.) were unified in addressing and resolving the novelty to support the program timing. A striking characteristic, that shows some correlation to reducing the amount of time expended with the surfaces changes, is this OEM's requirement that Studio personnel are originally trained engineers. This training from an engineering perspective appears to provide a high level of knowledge and understanding that avoids costly surface instigated changes.

Other observations noted are that once Program N, not matter which area arrived on the decision, once a decision was concluded the decision was not re-investigated, or reopened again. 'Dead bodies were allowed to be buried, not resurrected again' by various groups with the OEM. The mindset of the organization to keep prior decisions, avoided time and resources and produced positive reinforcement in the role and responsibilities of all the participants, and validity and respective expertise and knowledge. This is another anomaly to what has been characteristically

seen with the first 3 cases. The first three cases, the interviewees lamented about how difficult it was to stay with a set course, due to various other areas within the OEM 1 trumping prior made decisions.

Similarly, comparing both OEM's working through equivalent build events another anomaly was identified. Program N had on average, less number of meetings to drive resolution of issues. For example, on Program N had an average of 3 meetings/week, which averaged ~ 5 hrs/week (+/- 10 hours –if filibuster meeting occurred). Compared to Program B on average had 31 meetings/week which averaged 35 hrs/week (+/-6 hrs/week). This appears to indicate that Program N had more time to complete the engineering specifics (to develop and design a feasible design) while Program B had more time spent in meetings thus it can be concluded that additional time and resources need to be expended for the engineering specifics. This also seems to demonstrate that the objects and artifacts being utilized may be more effective in managing novelty (specifically since Program N had to encounter various language barriers to translate information).

This novelty, although originally unpredicted by the program –once specified as program direction was recognized by the team, and anticipated. The team understood implicitly the program's necessity to implement these changes (the syntax of the 'Tender Spec') and the consequences if the solution was delayed or unsuccessful. This shared meaning of the goal, this translation allowed a feasible design to be created. Past experience, understanding of the subsystem dependencies, and forecasting the impact of to the interior subsystems allowed the team to address and resolve the novelty within the interior trim environment.

Classifying the novelty seen in this situation within the hierarchy levels, expected novelty is exhibited, a Level 1 type. The capacity, the infrastructure to resolve this problem was assumed to be available and capable of addressing this novelty. The semantic boundaries existed due to the changes in the exterior architecture ambiguity occurred in the knowledge and the dependencies of the interior subsystems. The subsystems when faced with the novelty presented modified their respective designs. The organization's capability existing within the current system was able to support the late exterior redesigns; since the current process and infrastructure had some accessible knowledge that when translated addressed the novelty and created a solution.

The process in the form of the two weekly meetings, resolved the challenges. These informal small sized, meetings were more successful in encouraging interaction and participation from the participants. The computer renderings provided the primary mode of communication across physical (remote locations), mental (understanding different languages) and part boundaries. This established common language allowed the participants to translate the novelty into knowledge that was used to identify problems at the interfacing subsystems. The problems discovered were presented as subsequent topics at these standing meetings. Communication via the Communication sheets and PDR's provided written communication and documentation of how the design evolved. These meetings, and the objects utilized allowed the influx of knowledge to support and resolve any given subsystem problem.

Once the exterior and the safety canopy design were finalized to specific locations and dimensions, the designs for the other interior subsystems (e.g. the upper C-pillar trim, the headliner, the package tray) were developed. The designs from the safety canopy and the exterior architecture provided the framework that allowed the design of the interior subsystems to ensue, due to specific dependencies acquired. Specifically for the upper C-pillar, final shape, contour and attachment points were finalized. The development of a common understanding to resolve the novelty allowed the participant to overcome the semantic boundary. By defining the exterior systems, and the safety canopy the interior novelty was resolved by reducing the number of unknown dependencies. The established infrastructure and processes supported the rigorous program timing, and the common unifying goal to resolve this novelty and create an attractive product allowed the resulting changes to be resolved and transformed by the affected systems.

6.5 Tweeter Design

6.5.1 Technological Familiarity Matrix

This company's familiarity with this technology and its core market, the following assignment is seen, below in Figure 14. The company's current 'base market' is developing an interior system environment pleasing to consumers. If the company did not change its interior overmuch, it is inferred that it remains in its base market. However, if the interior of the vehicle is entirely redesigned (by familiar means and processes), the vehicle has the potential of attracting a different market segment, and is assigned into the 'new, familiar' quadrant on the y-axis. For clarification, the interior environment defined here is the hard trim.

This company's "base technologies" were seen to include its internally developed infrastructure to support changes. Since this change occurred on a prior program it is assumed that the company has some familiarity and/or history with this technology/design thus, on the x-axis, the design is aligned in the in the 'base' region.

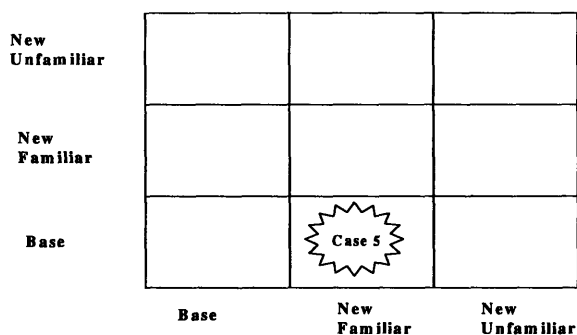


Figure 14 –Familiarity Matrix for Case 5

Novelty introduced was due to improving the aesthetics of this existing system. From the matrix it can be inferred that the skills, resources and organizational capacity required was adequate to address this kind of novelty.

6.5.2 Objects/Artifacts

Only two weekly meetings managed the issues involved with this change. These meetings were the kobeya and the obeya (see Table 5 below). The meetings were held in Michigan with the team members flying from all over the country and from Japan to support these meetings.

Meeting Type	Location/ Chaired	Frequency	Function	Tools/Artifacts	Actions
Kobeya	Toyota/ Manufacturing Module Leader	Weekly, Tuesdays	Design Feasibility of Interior Trim Systems	Agenda, Hard copy of meeting notes Paper drawings, hand sketches, parts	All participating Manufacturing side: Module Leader, Plant Assembly, Plant Quality, Product Engineering Group (specified area), Design side: Design Project Leader, Designer (specified area)
Obeya	Toyota/ Design Leader	Weekly, Thursdays	Resolution of Cross-Functional Issues	Agenda, Meeting minutes, Hard copy of meeting notes, and Open Issues List (Tracking) Paper drawings, hand sketches, parts	All participating Manufacturing side: Module Leader(s), Plant Assembly(s), Plant Quality(s), HQ Product Engineering Group(specified areas), Design side: Design Project Leader, Designer (specified areas)

Table 5 –Case 5 Types of Cross-Functional Meetings

For the kobeya, the working level weekly meeting an emailed agenda announced the topics to be addressed. Hard copies from the meeting were provided to all the team members that contained the proposal developed, the next actions, the responsible parties and closure dates.

These action meetings became the forum to resolve complicated interdependent system issues. Meeting form tended to be informal, and clustered around an open table that allowed drawings to be laid out for the team to review. The amount of participants supporting the meetings ranged from 8 – 10 regular participants with other additional designers attending if required. The assistant manager may attend however rarely did. If the proposal was no reconciled or impacted additional subsystems not typically invited to the kobeya, the issue was elevated to the obeya meeting.

The tweeter design was presented as a problem in the kobeya meeting. A number of proposals were developed and populated into a Decision Matrix. These designs captured on the matrix were translated into mocked up designs. These designs were reviewed by the kobeya (and later the obeya group once the design was refined) using the process of *genchi genbutsu*, translating into 'go and see' the actual process of prove out. Using *genchi genbutsu* the final design was reviewed and approved by the team.

With the tweeter design, the novelty thought to be reconciled was again encountered during the advent of Stage 3, and was thus scheduled as a topic item for the obeya meeting. The weekly obeya meeting was in an actual meeting room scheduled around a large table however, the number of participants increased to 20 – 30 people. The obeya meeting covered proposals that impacted multiple functional areas, or the top (A-ranked) critical issues for that specific system (e.g. interior trim). Though rare the general manager sometimes attended this meeting.

An interesting observation is that the participants involved with the kobeya and the obeya meetings were all working level team members. Coordinators, assistant and general managers

may have attended these meetings, however rarely attended them. This indicates that the team members were truly empowered with respect to their functional areas to make immediate decisions. This contrasts to OEM 1 that required supervisors, and the chief engineer to reconcile decisions.

Other similarities to OEM 2 that contrasted to OEM 1, were the average number of meetings held per week and the solid adherence to decisions made. Meetings on average lasted approximately 2 hours long. Once decision was made, clear and specific directions were given on how the design was to change. These concrete decisions were developed and rarely reconsidered by the process of *nemawashi*, literally meaning, "preparing the soil". Team members would solicit input and consult affected groups prior to the kobeya and/or obeya meetings in order to gain agreement on the proposal. This process allowed the proposal to be formulated with input from all the parties, gained consensus without hindrances or disagreements from the various groups.

Due to the involvement, expertise, and empowerment of the team members, along with the smaller group size changes appeared to be effectively managed in these meetings. The objects utilized, the part drawings, sketches, the Decision Matrix and the DIR's provided a process that recorded and resolved the changes occurring. "A picture says a thousand words" –OEM 3 uses many visual cues within the Decision Matrix, DIR's, A3's and A4's. These pictures, figures and graphs permitted the participants to identify the issues and were extremely effective to communicate and convey problems through different language barriers (Japanese, and American communications). The meetings, and the objects utilized allowed the knowledge to be resolved for any given subsystem.

6.5.3 Management of Novelty – Dynamics

Program T's team during a drawing review in Stage 1 identified an installation problem with the new tweeter design. This design was recognized as being problematic from a prior designed vehicle program. The novelty was addressed with a proposal and appeared to be reconciled. However the novelty arose again during Stage 3, due to styling changes that invalidated the purpose of the new proposal. This proposal was still maintained but required modifications to the A-pillar, wiring harness, sheet metal attachment points, and assembly installation sequence.

These modifications allowed the A-pillar to package the tweeter, and the systems behind it (e.g. moon roof drain tubes, safety canopy, and wiring harness) that allowed the part to be assembled and installed successfully. The safety canopy, one of the most critical systems in the interior due to its regulatory requirements, and the moon roof drain tubes due to its functionality requirements were not modified. The A-pillar, the wiring harness and the sheet metal had to change to accommodate the new tweeter design. Since this novelty was seen on a prior program, Program T made the assumption that novelty introduced by the tweeter design would be easily managed with the capacity and the supporting infrastructure of the organization and its suppliers.

The team members in the kobeya were unified in addressing and resolving the novelty presented, and to support the program timing. A striking characteristic is seen when comparing Figures 4 and 5. In Figure 4, in resolving the novelty encountered there appears to be many more *inputs* than *outputs*. When viewing the organization structure the interviewee from OEM 3 commented

that there are "too many voices at the table giving too many directions". Instead as seen by Figure 5 there appears to be only one boundary interface between the manufacturing (developing creation of the interior part) and design (the actual feasibility matched to performance). The team leaders from manufacturing and design become the filters to create 'one voice' to relay information and priority of requirements to the other side.

Similar to case four, once Program T, arrived and made a decision within these meetings, the decision was not re-investigated, or reopened. The consistency of the organization to maintain prior decisions, avoided time and resources and produced positive reinforcement in the role and responsibilities of all the participants, validity of their respective expertise and knowledge.

Comparing OEM 1 and 3 working through equivalent build events another difference was identified. Program T had on average, less number of meetings to drive resolution of issues. For example, on Program T had an average of 2 meetings/week, which averaged ~ 4 hrs/week (+/- 2 hours), compared to Program B on average had 20 meetings/week which averaged 25 hrs/week (+/-8 hrs/week). This indicates that Program T like Program N had more time to complete the engineering specifics (to develop and design a feasible design) while Program B had more time spent in meetings. Thus it can be reasonably concluded that Program B is utilizing additional time and resources for the development of the engineering specifics. Since the objects used with this OEM are different from the preceding cases, this demonstrates that the process and the artifacts are extremely effective in managing novelty.

This novelty, although originally unpredicted by the program –once identified was recognized and resolved by the team. The team understood implicitly the program's necessity to develop a solution (the syntax of the drawings) and the consequences if the solution was unsuccessful. This shared meaning of the goal, translated into a Decision Matrix of possible solutions allowed a feasible design to be created. Using *genchi genbutsu* (in the form of mock-ups), past experience, understanding of the subsystem dependencies, and forecasting the ramifications to the interior, electrical, and sheet metal subsystems allowed the team to address and resolve the novelty within the kobeya and eventually the obeya forums.

Classifying the novelty seen in this situation within the hierarchy levels, expected novelty is exhibited, a Level 1 type. The organizational capacity, the infrastructure, the actors to resolve this problem was assumed to be available and capable of addressing this novelty. The semantic boundary existed due to the changes in the tweeter design, created ambiguity in the knowledge and the dependencies of how the tweeter, along with other systems would be assembled and installed. The subsystems when faced with the novelty presented, modified their respective designs. The organization's capability existing within the current system with modifications was able to support the design changes; since the current process and infrastructure had some accessible knowledge that when translated addressed the novelty and created a solution.

The process in the form of the two weekly meetings, resolved any new challenges. These meetings were successful in encouraging interaction and participation from manufacturing and design engineering. The meetings provided the primary mode of face-to-face communication across physical, and the drawings provided the medium for understanding mental (understanding different languages) and part boundaries. These weekly forums allowed a common language to

be developed among the participants to translate the novelty into knowledge that was applied to identify and resolve problems at the boundaries. The problems discovered were presented as subsequent topics at these standing meetings. These meetings, and the objects utilized allowed the influx of knowledge to support and resolve any given subsystem or organizational boundary problem.

Once the proposal was defined from Stage 3, the refinement of this system was allowed to occur with final subsystem designs were established. Due to specific dependencies the safety canopy and the moon roof drain tube design remained unchanged. However modifications were required to the electrical, sheet metal and the interior trim subsystems. In particular the A-pillar trim the final shape, contour with the tweeter component, the attachment points and installation sequencing were finalized. The development of a common understanding to resolve the novelty allowed the participant to overcome the semantic boundary. By defining the assembly and installation issues the tweeter novelty was resolved by quantifying the number of dependencies, and generating a list of potential solutions. The established infrastructure and processes supported the deadline of the program, and the common forums (the kobeya and the obeya meetings) allowed an active avenue to have the critical experts available to resolve the novelty.

7.0 OBSERVATIONS

7.1 General Observations

Japanese automotive manufacturers lead in product development time utilizing fewer engineers. Engineering is not co-located, or dedicated specifically to one program. This indicates that the tools and/or process employed are different from those used by its competitors. Observations noted from interviews, research and literature indicate the following differences:

1. **EXPERTISE:**
 - a) Time to develop experience is aligned to a specific area to form an expertise (it is highly unusual to have a cross-functional assignment during the 1st 20 years of an engineer's career).
 - b) Management has a deep technical background, and is expected if required to perform the tasks of the workers they supervise. Technical engineering is considered one of the most important aspects of their job performance.
 - c) Management's most important assignment is to develop the employees they supervise. Supervisors will rarely make a decision for a subordinate –instead Socratic questions are given to allow the employee to 'search' for the answer.
 - d) Chief Engineers perform the role of integrator across functional groups. However, the functional areas have the expertise and knowledge and make the critical performance decisions.

2. **COMMUNICATION:**
 - a) Written communication via A3/A4's and Communication Sheets boil down the salient issues, and the necessary data that allow all involved participants to have a shared beginning, and understanding of the problem.
 - b) These documents show the status of other organizational boundaries and indicate the progress to improve these problems (e.g. DIR's).
 - c) Standard documents derive much of their meaning based on visual information e.g. pictures and graphs.

3. **DESIGN PROPOSALS:**
 - a) 80% of time is spent planning the change, while 20% is spent in execution or rework.
 - b) Japanese development system focuses on generating large number of alternative designs, whereas North American automotive manufacturers review alternatives and quickly focus on a single solution
 - c) Different participants are independently defining new proposals from their respective perspective and expertise. From these different points of view, the participants look for the areas of agreement where these alternative proposals align in ideas and concepts.
 - d) Established system allows frequent communication.

An example of simultaneous engineering in practice 1997 was not a fortuitous year for Toyota. That year Toyota suffered a catastrophic failure when Aisin Crisis, the part supplier of the valve component (essential to the braking system) burned to the ground overnight. This valve was a

common component used on all the Toyota vehicle lines, and was only a stocked for supply available for three days (due to just-in-time inventory). Toyota's production of over 15,000 vehicles per day would be curtailed if disaster were not quickly averted.

To rebuild a new plant would take a duration of six months, and was not a viable alternative. What does Toyota do? Toyota along with over 200 other supplier companies reorganized themselves to develop at least six different production processes, employing different engineering methodologies, and tools. Based on the collective ability of these participants to react quickly, within three days, production of the valves was back on line, and within a week production levels regained the capacity levels prior to the disaster.

This is different from the method of working in a singular fashion, of selection of an option after considerable review, and developing that specific proposal. Problems develop when additional knowledge is translated from various groups into the design, creating significant changes and further analysis to determine whether the design still manages to perform its intended function, in addition to the needs and/or changes from other groups to this design.

4. DESIGN CHANGES:

- a) The changes made in one part will not unduly affected other parts due to the nested modular organizations (akin to the Russian wooden doll effect, changes are encapsulated to impact only a certain system not all).
- b) Design for manufacturing and assembly is captured first hand for part development based on the input from team members in the kobeya meetings.
- c) The organizational structure is laid out as a project organizational structure. Based on repeated development cycles the core team members become adept at identifying boundary issues specifically with the novelty encountered or from differences and dependencies of the participants.
- d) Working level engineers are empowered to make decisions. Once these decisions are made the organization does not revisit these agreements.

5. MEETINGS:

- a) The team members involved in the kobeya are recognized for the expertise they bring from their respective areas. Since all the team members contribute to the design solution and incorporation the members have a vested interest to resolve the problems as a team, not a separate organization.
- b) Changes are facilitated in the kobeya with the module leader as the principle actor to facilitate the design boundaries and the numerous informational inputs from manufacturing.
- c) Less time is spent in meetings and more time is expended in creating the design changes. Secondary activities are uncoupled in the creation of a feasible design (e.g. finance, purchasing are not the primary focus for designing a solution).
- d) Smaller meetings compared to larger meetings seem to be more effective in the management of novelty.

7.2 Case Observations

The table below provides an abridgement of the five cases discussed in this paper, and other singular characteristics.

Features	Case 1 (OEM 1)	Case 2 (OEM 1)	Case 3 (OEM 1)	Case 4 (OEM 2)	Case 5 (OEM 3)
1. Organization Structure	Functional Organization	Functional Organization	Functional Organization	Functional Organization	Project Organization
2. Novelty Level	1	2	3	2	1
3. Boundary Type	Syntactic	Semantic	Pragmatic	Semantic	Syntactic
4. Artifacts					
a. Program Content	PDL	PDL	PDL	Tender Spec	Spec System
b. Problems	8-D	8-D	8-D	PDR	DIR
c. Prior to Meetings	Emailed Agenda	Emailed Agenda* (depended on meeting)	Emailed Agenda	Emailed Agenda	Emailed Agenda
d. Used in Meetings	Computer Sections	Computer Sections	Computer Sections	Computer Sections	Part Drawings
e. From Meetings	Email	*Meeting Minutes	None	Communication Sheet	Hard copy of meeting notes
f. Part Change	WERS	WERS	WERS	XL Notes	Engineered Change Instruction
g. Cross-Functional Decisions	~CNE Sheet	~CNE/AST Sheets	~CNE/AST Sheets	Unknown	Decision Matrix
h. Summary of Event	~Stage Review	~Stage Review	~Stage Review	Unknown	A3's/A4's
5. Process					
a. Time in Meetings	4 +/- 2 hrs/wk	35 +/- 6 hrs/wk	10 +/- 2 hrs/wk	5 +/- 10 hrs/wk	4 +/- 1 hrs/wk
b. Location	Room	Room/Desk	Room/Desk	Desk	Open Table (like Desk)
c. Org Capability	Medium (strong org)	Low (strong org, no actors)	High (strong org & actor)	Low (strong org, no actors)	High (strong org & actors)
d. Revisit Decisions	Yes	Yes	Yes	No	No
5. Team Structure					
a. # of Participants	Avg. 12 +/- 5	Avg 20 +/- 10	Avg 15 +/- 5	Avg 8 +/- 5	Avg 10 +/- 2
b. # of Actors	None	None	1 (Supplier)	None	2 (Module & Project Leaders)
c. Amt of Difference	Low	Medium	High	Medium	Medium
d. Amt of Dependency	Low	High	High	High	Low
6. Knowledge Creation					
a. Creating	Suppliers	Suppliers	Suppliers	Suppliers	Internally in OEM
b. Acquiring	Package Meetings	Via Meetings	'SWAT'	Via Meetings	Kobeyas
c. Disseminating	Computer Sections	Computer Sections	Computer Sections	Computer Sections	Via Meetings, A3's
7. Miscellaneous				Studio Personnel have engineering background	Limited support of Suppliers, Purchasing & Finance

Table 6 – Summary of Case Study Characteristics

From this table it appears that the need for actors is essential to filter priorities and to drive pragmatic boundaries. Based on competitive pressures to reduce time to market, a successful contributor to this goal is to have primary actors to filter the inputs and facilitate communication amongst the different groups. OEM 3 uses two primary actors. For example, one actor the interior trim module leader filters information from manufacturing and the product-engineering arena while the other actor, the project leader interfaces with the designers. This creates only one interface between the various groups expressing emerging issues, and is further illustrated when comparing Figures 4 and 5.

Comparing only Level 2 novelty, another significant pattern is prevalent in the sheer number of participants involved, and the amount of meetings required to facilitate resolution. More resources are being expended in a large quantity of meetings for OEM 1, in contrast to the amount utilized by OEM 2 (this is also exhibited to a lesser extent when comparing Level 1 novelty of OEM 1 to OEM 3). This implies that there is a boundary, a greater gap or difference in the knowledge known and understood among the participants. Logically this makes sense, the larger the pool of people attending the meetings the greater the difference in the knowledge,

skills and expertise of the participants. This seems to indicate that the organizational infrastructure and/or the actors involved for OEM 2 and 3 maybe more effective in one or both areas, thus strengthening their organizational capability.

The use of artifacts aids the transformation of information into knowledge. Each of the OEM's employ different documentation standards however, in all cases schematics in the form of computer renderings and/or part drawings was the primary medium to facilitate the boundaries. OEM 2 and 3 utilized more graphical and pictorial elements within their respective document standards. These visual elements were more easily understood and reduced logistical problems of misunderstood word meanings and mistranslations. For the content that was written, there was a pattern in the consistency of the format and penurious use of words.

From the cases, OEM 2 and 3 further strengthen their organizational infrastructure by not revisiting or challenging past decisions. With OEM 3 the participants involved in the kobeya meetings are empowered to make the decision for their respective areas. These participants are recognized by their respective departments in 'carrying the voice' of their issues. The mentality to maintain mutually agreed upon decisions reduces the amount of time spent on the preparation and defense of these decisions but, also provides credence to the process and respect for the knowledge and expertise of the individuals involved to create the decision.

Additionally both OEM's augment their respective organizational capability by involvement of key areas critical for the design development process. For OEM 2, the difference (or the gap) in knowledge is lessened by employing designers with engineering backgrounds. With this approach infeasible iterations requested by styling have been eliminated, and lessened the time required for appearance approval. OEM 3 similarly requires the operator (responsible for installation) from the assembly plant to attend all the kobeya meetings. An indirect reinforcement of the genchi genbutsu principle 'go and see' (e.g. if there is a problem the kobeya meets at the plant to resolve the matter). With this critical participant the information of the manufacturing process has been added to the collective team, and over time strengthens the organizational capacity since this information is diffused to other participants and creates knowledge.

OEM 3 further reduces their time to market by not making the financial aspects the singular decision for design changes. Supplier involvement in the kobeya and obeyas is also minimal. The design side of OEM 3 interfaces with the suppliers however is primarily responsible for the design of the parts. Supplier involvement typically occurs when late stage problems arise that requires additional expertise not known by OEM 3's designers. This is in contrast to the high reliance on the supplier base used by OEM 1 and 2. This methodology further accentuates the core values of these companies.

For instance, OEM 1's underlying concept is value, whereas OEM 3 stresses a more holistic approach and understanding of the downstream effects to the entire system. This translates to how these automotive manufacturers interface and interact with their supplier base, and in turn how these suppliers respond back. For OEM 1 the supplier is involved early on and provides solutions best suited towards their design and manufacturing methods. The supplier is conditioned to provide 'cost conscious' proposals thus what is selected is typically the lowest cost

alternative. Whereas OEM 3 develops the design proposals and reviews the ramifications to their assembly and installation process (and other important factors), then chooses the optimum alternative based on the criterion. It is argued that this methodology, reviewing the component design to system level impacts is more holistic and reduces quality and systemic problems.

Additionally OEM 3, with the only project organization structure has become proficient in recognizing boundaries, and cross- functional problems. Participants sole responsibility is to design the vehicle, not launch it. Launch and actual builds of the vehicle are handed off to another group after a small number of non-saleable vehicles are constructed. Thus, this team becomes the experts at designing vehicles.

7.3 Proposed Triage

Overall, the analysis of the case studies provided an interesting opportunity to review the design processes of various OEM's and how the novelty encountered becomes engaged, and managed. It was postulated in the beginning of this document that using the Roberts-Berry Familiarity Matrix, Carlile's 3-T Framework and Gilbert's Hierarchy of Novelty a triage tool could be developed to diagnose before or at the onset of novelty introduction. The three tools independently provide critical information that is important for novelty management.

The Familiarity Matrix establishes an approach to plot a company's familiarity with respect to the market segment and the technology being leveraged. The matrix can be employed to see how a company's technology, strategy or other business decisions compare to established company products –and provides an indication of how prepared the company is in managing innovation. This matrix has been used in the past for determining the strategic positioning of a company in relation to its competitors. The information it can provide assists in understanding the impact of the novelty with respect to the market the company is targeting, and the technology being employed. Novelty encountered within all these five cases is a result of a technological change. The technological changes created boundary issues, thus producing novelty.

The 3-T Framework links this relationship of novelty and boundaries and the increasing complexity of managing knowledge. Carlile's 3-T Framework creates a categorizing system for describing the situations that can occur between the type of boundary encountered, and the type of process employed. Three types of boundaries are described: the syntactic, the semantic and the pragmatic. These boundaries manage novelty by the process of: transference, translation, and transformation. The cases studied in this document demonstrated the different types of boundaries and processes encountered.

Gilbert further supplements Carlile's concept by presenting four levels of novelty. Level 0, the syntactic boundary creates minimal novelty and no changes are required to change the infrastructure. Level 1 defines novelty that is anticipated, and the infrastructure with modifications can manage the semantic boundary as seen with cases 1 and 5. Level 2 describes the condition that novelty although expected is underestimated. The organizational capacity and ability in its current condition will impede novelty resolution. To manage this semantic boundary the organization infrastructure needs to be adapted to the new content as shown in cases 2 and 4. Lastly Level 3 defines a pragmatic boundary condition in which the no organizational infrastructure or capability exists to handle the novelty. This type of example was

seen with case 3, in which a company strategy created novelty with a part that radically changed the organizational infrastructure and created capability for the newly designed part.

An organization can exercise the use of these tools to assess and prepare any situation. This document has provided evidence that by combining the concepts from the Familiarity Matrix, the 3-T Framework and the Hierarchy of Novelty a triage tool can be developed. This tool can be used to assess the level of novelty encountered and allow the organization to forecast resources and prepare for organizational infrastructure changes. Based on the cases studied, the novelty aligned in the following areas, seen in the Figure 15 below.

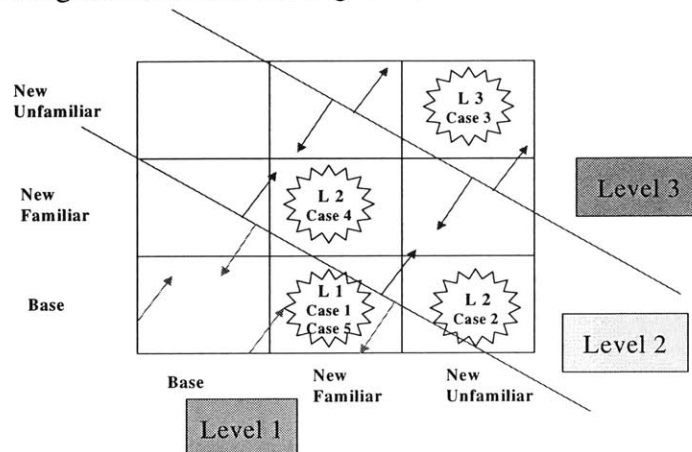


Figure 15 – Triage Assessment for All Cases

From these case studies, the levels of novelty can be aligned on the Familiarity Matrix, thus creating a gage index that permits organizations to predict the types of novelty that can be potentially encountered. This triage tool is valuable in that it graphically represents the latent gaps or boundaries among the participants involved in the passage of altering information into innovative knowledge. These boundaries represented by the hierarchy levels represent disparate levels of knowledge, the difference among the participants. The larger the boundaries the more difficult it becomes to use the existing organizational infrastructure.

An organization utilizing the regular infrastructure (reuse of existing the artifacts) the organization entertains the risk that these historically successful boundary objects can actually impede the representation of new forms of knowledge needed to drive innovation across specialized domains (Carlile and Reberich, 2003). This impediment is bred from the rigid core competencies of a complacent organization unwilling or not recognizing the necessity to change and become flexible to the stimulus of a dynamic consumer market using its organizational capability to modify these informational inputs into knowledge innovation.

Thus the organization is challenged to walk the pathway of preserving flexibility, a *nimbleness* to alter its behavior while still managing an efficient infrastructure. This appears to be a contradiction however the goal of an organization is to locate this optimal equilibrium, akin to the golf term, the 'sweet spot'. This document has represented *snapshots* of the development processes of various automotive manufacturer accrue of novelty in the search for the ideal organization infrastructure that presents an optimal meld of structured processes and flexibility.

These case studies have provided insightful information that organizations can internalize and employ to improve their organizational capability.

8.0 CONCLUSIONS AND RECOMMENDATIONS

Similar to Chapter 6 this section will evaluate the areas of the: Technical Familiarity, the Objects/Artifacts and the Management of Novelty - Dynamics for all the cases to identify any prevalent patterns or anomalies and will end with conclusions and recommendations.

8.1 Technological Familiarity Matrix

Positioning the market segments of the cases to the technological familiarity, if all the assessments of the cases are combined and added onto one matrix, the figure below demonstrates the results of this exercise.

New Unfamiliar			L 3 Case 3
New Familiar		L 2 Case 4	
Base		L 1 Case 1 Case 5	L 2 Case 2
	Base	New Familiar	New Unfamiliar

Figure 16 – Technological Familiarity Matrix for All Cases

The following resultants are found:

- Case # 1 and 5 are positioned in the same quadrant.
The rationale behind this placement is that both cases dealt with the same market segment (customer base) and the technology, although different was familiar to the organizations involved managing the innovation. For Case # 1 involving the late addition of the SDARS feature, the market segment for this feature remained unchanged however, the feature although different from the current technology was not unique or novel enough to require changes to the current organizational infrastructure. Case # 5 similarly, provides another example of a prior technology that was encountered. Although the event is novel, this program's organization was intrinsically familiar with the tweeter design that enabled it to resolve the issue within the organizational infrastructure. It can be concluded that the organizational infrastructure with its current capacity was able to manage these changes.
- Case # 4 is found in the middle of the matrix.
The new, familiar region for both the market segment and the technology correspond to this innovation. The justification for this alignment was based on the premise that the interior content was drastically altered due to the changing exterior structure. The changes both to the exterior and interior environments were required to enhance and attract new consumers. The innovations required for these changes utilized technology that exploited the existing organizational infrastructure however, alterations were required to facilitate this innovation.
- Case # 2 is situated in the lower right-hand corner.
Although the safety canopy design involved the same consumer market (no significant changes for the interior parts for other events) the novelty of the new technological

requirements encountered was unanticipated. Thus the alignment of this novelty is within the base market on the x-axis and the 'new, familiar' area on the x-axis. Similar to Case # 4, the novelty found here required additional time, and modifications to the existing infrastructure in order to implement the safety canopy design.

- Case # 3 is positioned in the upper right-hand corner. The positioning is based on the complete novelty of a new corporate strategy that changed the market segment and the technology being implemented. The market segment is scoped to define the overhead system, and the technology involving new suppliers to implement revolutionary strategy. This change is unable to be managed within the current infrastructure and requires involvement from other resources outside of the normal process. The heroic efforts from the primary actor also facilitated improvements and final design conclusion.

In the course of this paper it was postulated that the use of this matrix, in conjunction with the concepts introduced by Carlile and Gilbert created a tool combining all three applications offering a 'magnifying lens effect' on the perceived novelty. One of the precepts of the triage method, the application of the matrix as seen in Figure 16, provided a simple graphical presentation in plotting the novelty of an event based on the market segment and the technology involved.

8.2 Objects/Artifacts

This document reviewed and compared five cases involving the management of novelty with three automotive manufacturers. Some commonalities that have been found are:

- Face-to-face meetings were extremely critical for the resolution of the novelty that one OEM for example would actually 'fly in' to the destination all the participants for the weekly meetings.
- *Fewer* meetings with a *limited* number of *specialized* team members tended to create a **controlled** informal environment conducive for novelty management.
- *Fewer* meetings it is concluded allowed for further reflection on the novelty and its influences on other supporting systems.
- Depending on the stage of the program development specific objects was utilized for novelty: introduction (e.g. program direction letters, tender specs, spec system), discussion in meetings (e.g. emailed agendas, list of open issues) resolution of boundaries problems identified later in stages of development (e.g. project development records, design investigation request).
- A common language with recognized meanings implicitly understood by the participants was the medium to initiate novelty resolution.
- The medium used in all five cases utilized a visual spatial configuration to model the parts and represent the novelty. This typology established a relationship between form and space. In 4 out of the 5 cases the medium primarily utilized was the computer renderings. In Case # 5, sketches and mocked up parts were equally sufficient in driving and resolving the novelty. It is surmised that this contradiction is elucidated by the primary use of permanent actors that facilitated the cross-functional boundaries between two disparate organizations.

Results from this study indicate the prevalent usage of objects/artifacts in meetings to negotiate boundaries between different specialized communities (e.g. different subsystems) and the

management of novelty resolution. A boundary object can inhabit different specialized communities, but adapts to the local needs and constraints of the team involved to develop a final solution. The artifacts employed in these cases contributed to the design evolution and permitted the collaborative information (represented within them) to be submitted, analyzed, criticized, and refined (the artifact itself) repeatedly until achieving the final design.

The visual representations (e.g. computer renderings and sketches) were integral in exploring new concepts and creating a common understanding by transforming other ways of knowing information (from verbal and mathematical modes) into a visual format. This visual format (the typology) allowed the tacit knowledge from the participants to be shared and represented in a format understood by all resulting in the creation of: alliances, venues for information exchange, and compromises on specific problems.

8.3 Management of Novelty – Dynamics

The approach engaged by these OEM's to address and resolve novelty differs markedly. Differences include:

- Maintenance of past decisions. As seen in Case # 4, 'dead bodies were allowed to be buried not resurrected again' by various groups. The emphasis to adhere to past decisions permitted the development process to gain validity in resolving novelty.
- Amount of meetings to resolve novelty during a similar build event. On average OEM 2 and 3 required fewer meetings to resolve the problems. The information from the cases reveals that OEM 2 (Program N) and 3 (Program T) only required 2 meetings/wk compared to OEM 1 (Program B) requiring an average of 31 meetings/wk.
- Utilization of filibusters. OEM 2 used this approach in meetings if the novelty was not reconciled to formulate a feasible direction.
- Employment of the *nemawashi* process. OEM 3 consulted diverse cross-functional areas until a consensus was achieved on the proposal.
- Reduction in the number of inputs developing designs by controlling the information inputted during development. For OEM 3, two principal actors through facilitation, prioritization and mediation functioned as the gatekeepers of innovation accomplished this duty.
- Communication to the right contacts. Recognition and involvement of the right people and time appeared to be easiest with OEM 3. It is inferred that the project organizational structure and the task force that centered specifically on development (not launching the programs) allowed this group to achieve specialization in the product development as a specific function.
- Exploitation of the principle of *genchi genbutsu* 'go, see'. OEM 3 team members experienced the problem firsthand in order to grasp the implicit and tacit information of the factors, and dependencies to create a versatile solution.

Presently the novelty met in all five cases appeared to be managed successfully within the programs. Depending on the scale and the type of boundary encountered the organizations addressed the dilemma by supplementing, modifying or changing the organizational infrastructure to fulfill the needs required to manage the novelty. In the majority of the cases the supposition was made to employ the present organizational infrastructure. In three of the five cases the organizations implicitly assumed that the organizational capability existed to address

emerging issues. The cases reviewed provided a diverse range of the levels of novelty encountered.

Case # 1 dealt with the SDARS feature representing a Level 1 (expected) novelty approach. The feature was added to the program fortunately, the existing organizational infrastructure was applied to the problem to develop a favorable design solution. The organization capability to was sufficient to handle this situation and the novelty encountered by the SDARS was resolved within any timing delays or additional resources. Additionally during the tweeter design, Case # 5 exhibited another Level 1 (expected) novelty with OEM 3. The problem encountered in this case is a new design that presents assembly and installation issues. The organizational capacity to resolve this dilemma is easily seen by in Stage 1 of Program N's design development and reaffirmed and checked in Stage 3.

On the other hand in Case # 2, the incorporation of the safety canopy system, the OEM 1 approached a latent (Level 2) situation as expected novelty (Level 1). Several observations from this case study support this view. First, the team affected by the new safety canopy curtain was tasked to use the current process. The organizational infrastructure was applied to find an optimal design solution however, insufficient information was known or identified early on to the program to warranty the justification for the expected novelty approach (Level 2). This was later confirmed during the packaging of the safety curtain by the occurrence of multiple design iterations for the system. Without system level specifications the infrastructure applied was ineffective to resolve the problem. Despite the efforts and ability of the participants involved the solution was not achievable within the desired timetable. With additional time, understanding, and modifications to effected subsystems significant progress occurred that allowed the team to develop a design solution. Wisdom gleaned from this study is the process capability to resolve product topographical issues is becoming inflexible and losing its relevance. The organizational infrastructure will need to change for future programs if similar novelty stimuli are applied.

The other case exhibiting a Level 2 approach was able to successfully incorporate the novelty due to the adequacy of the organizational infrastructure and the capability of participants and actors involved. In Case # 4 that involved entirely redesigning the c-pillar trim, OEM 2 although the program timing slipped for this novelty it was readily managed within the means of the organizational infrastructure. The supplier base given the time restrictions of the program developed an optimal design that resulted from the exterior architectural changes.

Lastly a Level 3 (white space) novelty approach is observed in the incorporation of a new system strategy with the overhead system in Case # 3. The existing organizational infrastructure was recognized as an unable to support the development of this new system. New processes taken in the form of the SCT and 'SWAT' meetings facilitated the design development of the overhead console. This overhead console system was further refined, by the care and involvement of the principle actor, the supplier. With expertise, this supplier filtered the many streams of information to generate knowledge and create an innovative design for the overhead console system. The organizational capacity was expanded and transformed by the novelty encountered. The organizational infrastructure was flexible to change to this problem, and as a result enriched the organizational knowledge base.

Based on all these studies it is important for product development organizations to enable its infrastructures with the enough capability for novelty introductions. Strategies that impact the organization also increase the level of novelty encountered. Practicing the use of the triage tool will increase the organization's chance to identify novelty and strengthen the design and development process. Actors within the organization and the supplier base should be leveraged more frequently to merge top priorities of the team and manage knowledge innovation. Novelty when it arises and is recognized via the use of the triage tool, the actors and the organizational infrastructure could adapt to new stimuli, and contextual nature that the novelty creates. The organizational capability will be strengthened by these encounters since the creation of different experiences augments the organization's knowledge base. Due to a fierce competitive market, and the changing needs of the consumer it becomes essential for the development of an effective organizational capacity that is flexible to change to dynamic conditions.

8.4 Conclusions

The cases presented provide further credence that infrastructures enabling organizations to distinguish and resolve novelty enrich the organization's capability. Encountering change novelty is a vital dimension to the product development process and is important to the creation of knowledge and innovations. To maintain a dominant position in the today's market a company must leverage all its resources. Competitive pressures to improve quality, maintain consumer loyalty and reduce time to market create strong inducements to either maintain the status quo (utilizing current organizational capability) or to ignore novelty altogether when it is encountered by an organization.

An organization's performance how it accomplishes tasks against targets is linked to the concepts of organizational infrastructure and capability introduced in Chapter 2. Organizational capability includes the capacity of the infrastructure, and the ability of the team members (actors and participants) to manage change. Organizations generally are impetus, slow to change or adapt to dynamic conditions. As mentioned in the literary research review maintaining the status quo, core competencies become rigid. Rigidity leads to extinction if a company does not react to market conditions.

In order to react, an organization needs to recognize and anticipate novelty. By using the following tools: the Roberts Berry Familiarity matrix, Carlile's 3 – T Framework and Gilbert's Hierarchy of Novelty a diagnosis tool was developed that incorporated the salient concepts of each of these models into the triage tool (i.e., Figure 15). This tool can be used by organizations to identify the levels of novelty faced. Increasing novelty impedes the flow of knowledge within an organization's infrastructure. Information created into knowledge is pathway dependent and contributes value based on the contextual application. The introduction of novelty requires adaptation (i.e., translation and transformation) of the context and the importance of the knowledge acquired and maintained.

8.5 Recommendations

Recognizing novelty and employing the triage tool will assist an organization in preparing and dealing with the novel situation. Organizations need to welcome novelty and be flexible to change. The organization can augment the design development process to capture this triage

tool, or require the program management department to acquire this tool for new feature assessments. The triage tool once instigated provides a diagnostic of the level of novelty encountered, a refinement of the value criterion, and validation of the organizational infrastructure utilized to support the change. The person (or group) employing the triage tool needs to be proficient with the framework of design development and knowledge of process execution however not directly involved with the implementation. Having an oversight committee allows the organization or program to reflect on the ramifications, and influences associated with introduced changes.

Alternatively the product development organization can be involved earlier by utilizing the triage tool within each respective area. These separate appraisals can be filtered back to a functional leader to determine if there are disparate assessments on the level of novelty anticipated for two separate subsystems that are dependant on one another. For instance, the headliner subsystem and the electrical group would create assessments for these respective areas. The results submitted if markedly different, would require communication between the various groups to understand the scope of the expected novelty and the ramifications these changes would create for the other subsystems. The information gained should then be used to generate the program direction, content and assumptions and in turn, results in changes to the organizational infrastructure to manage the innovations. The use of the triage method with this process offers an early indicator of coupled subsystems that historically cause multiple iterations in design and development. Using a Design Structure Matrix (DSM) on the subsystem can discover these coupled events. The DSM (that will be discussed further in the next section) requires extensive time and resources. The triage tool it is proposed can be applied as a precursor or used in lieu of a DSM. However, the caveat of this proposed method assumes both areas know the full extent of the program assumptions (needs and wants). This further aligns the rationale to support the program management organization having full responsibility and management of this triage tool.

Once the novelty is diagnosed with the triage tool, the infrastructure and the participants require alignment (in goals and objectives) to the level of novelty encountered. Assumptions given in the beginning of a program are based on experience and assessments. It is important that the assumptions proposed are explicitly understood by all the participants in order to question the content, the validity of the change. As shown in the second case study the program direction for the new safety canopy went unchallenged and the program assumed it would encounter expected novelty (Level 1) however, the program actually faced latent novelty (Level 2). This further reinforces the necessity for organizations to fully understand the assumptions and question any ambiguities. The organization environment needs to be conducive to allow assumptions to be challenged, debated and even rejected if justification is not provided. The assumptions made in the beginning of a program can either support or confound the organizational infrastructure. Thus increased sensitivity to assumption creation and agreement to the content needs to be mutually agreed by all participants. From these assumptions the infrastructure and the resources are maintained, modified or created anew.

Additionally reducing the number of boundaries may control the innovation. OEM 3 has developed an organization that has one interfacing boundary between the manufacturing and the design areas. With the use of two principle actors (e.g. module and project leaders) this company has been able to successfully manage novel situations and create innovative solutions.

Nurturing expertise and the development of participants increased the capacity of this organization since these individuals were able to communicate on both sides of the boundary. Based on the strong infrastructure and the ability of its team members, it comes as no surprise that this OEM without sacrificing quality and reliability has one of the quickest design product development cycles within the entire automotive industry.

It is also extremely beneficial for organizations to recognize past mistakes. Acknowledgement and reflection that mistakes are possible becomes the first step to improve and strengthen an organization. The culprit (or group) that instigated the problem should not be blamed but assessed to determine the underlying root cause of the derailment (employing the 5 whys, what changed to precipitate the failure) once the cause has been identified, diagnosed, the culprit (or group) is treated and nurtured. Core competencies can be altered but participants cannot. With the regular use of assessment reports similar to A3/A4 an organization can track the management of boundaries and focus on areas needing improvement. This action additionally aligns with the PDCA cycle (Plan, Do, Check, Action) by strengthening the Check phase of the cycle.

The cases studied show a glimpse of the type of issues seen in the automotive industry when novelty arises. The OEM's infrastructures were compared and contrasted to illustrate differences in processes and all appear to still permit the successful management of innovation. There is no silver bullet or an ideal process. The theme to take away from this document is that any change impacts the organizational capacity. How to manage changes is addressed by the use of the triage tool. Once the novelty is diagnosed the organizational infrastructure and resources are maintained, augmented or reinvented to face the challenge.

9.0 FUTURE WORK

If further time permitted the author would have attempted to measure the interdependence of the various subsystems in some of the case studies by use of the Design Structure Matrix, DSM (Steward 1981; Morelli, Eppinger et al 1995). This approach utilizes a matrix that divides the issue into smaller subsystems and problems, and relates task dependency to subsystems. For example, when a particular subsystem requires the output of another subsystem or task, this is a coupled interaction and the matrix connects these two subsystems. This coupled interaction indicates a strong interdependency between the two subsystems. Similarly defining subsequent tasks, interdependency can then be measured by expected and necessary information inputs.

The information gained from the matrix is the amount of interdependency involved for any given task within a given project can be measured. The DSM employed can identify dependencies. This method can be used to augment the Novelty Familiarity Matrix since it allows organizations to compare from past to new programs the old and new dependencies, and as a predictor provides the dominant type of dependencies that can be found on projects. If new dependencies are encountered on programs this identifies to the organization that the current infrastructure requires modification and exploitation of new processes to manage the novelty. Otherwise maintaining core competencies without being flexible to dynamic changes leads to the organization to have core rigidities.

Additionally, while this work provides the integration of these novelties into the product, actual production of these vehicles will not be completed until 2005. It would be extremely beneficial to follow-up with these cases, and verify that the novelty incorporated into the product did not create any issues downstream in production. Based on the limitations of research oriented, and traditional project documentation structures the author recommends employing the learning history method. Organizations can easily deduce the 'know-how', however the 'know-why' is difficult to capture and understand. This type of knowledge relates to identity ("who we are"; "how things are done", "what mistakes occurred") and values. Organizations have their own idiosyncrasies that when "revealed and probed into, deeper more tacit basic assumptions which are tacit can be elucidated" (Roth, 1996). The learning history process enhances the organizations' learning capabilities by exploring the answers to these questions.

The approach combines all points of view in the development and/or resolution of innovation. It creates a narrative for a situation encountered; the critical issue, for example this could be a corporate initiative; a successful product launch; or an innovation. The perspectives given here (from participants from other departments) present valid, yet limited information that when combined together with other participant's perspectives, allows the organization to learn from the experience and understand the implications of these types of changes. The making of 'a learning history' is that the information presented in the document is viable to all audiences.

The information gathered involves insights that are not recognized and/or openly shared. The learning history involves a seven stage process that involves: selection of magnitude and scope; utilization of conversational interviews; distillation of data; development of the document; validation workshop of the document; dissemination of document; and lastly the impact of the document on improvement efforts. These steps, intend to increase and broaden the

organization's capability by providing a "forum for reflecting on learning and substantiating results" (Roth, 1996).

The document created ranges in length from 25 to 100 pages, and has two-column format (see www.solonline.org for a learning history example). The right hand column provides the primary data, the story from the participants involved with the event. The left hand column contains the analysis and commentary provided from "learning historians" (people trained in organizational learning) on the narrative given. Full text is used in the document to provide a contextual setting.

Since its inception in 1994, there have been over 15 learning history projects. Specific to the automotive industry, a new product launch exceeded expectations on meeting targets for quality (30% decrease in "things gone wrong"; 13% increase in "things gone right") and time to market (Job1 date moved forward). The learning history for this new product launch is a 200-page document portrays the story of this launch team, and shows the cross-functional interrelationships that achieved these spectacular results (Roth and Kleiner, 1997).

The learning histories have strongly indicated that in "reengineering, redesign, or quality efforts, the single most critical factor for success is the quality of human interaction in the organization" (Roth and Kleiner, 1997). This suggests that a learning history can be extremely powerful medium at transferring knowledge from one organization to another. Future work is suggested in this area, to further complement the work developed in this paper.

10.0 REFERENCES

- Allen, T. J. 1984. "Managing the Flow of Technology: Technology transfer and the Dissemination of Technology Information Within the R&A Organization", Cambridge, MIT Press
- Calkins, Su, and Chan, 1998. "A Design Rule Based Tool for Automobile Systems Design", *SAE Technical Paper Series 980397*, Detroit, MI
- Carlile, P. R. 2002. "A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development", *Organizational Science (July – August vol. 13, no. 4)*, pg 442 – 455
- Carlile, P. R. and Rebentisch, E. 2003. Into the black box: The knowledge transformation cycle. Forthcoming, *Management Science*.
- Carlile, P. R. 2004. "Transferring and Transforming: An integrative framework for managing knowledge across boundaries", *Forthcoming in Organizational Science*
- Cole, Roberts, Taylor and Vinarcik, 1998. "Integrating Product and Process Planning", *SAE Technical Paper Series 981330*, Detroit, MI
- Crawley, E. 2003. "Systems Architecture Lecture Notes"
- Cutcher-Gershenfeld, Nitta, Barrett, Sai-Chung Chow, Inaba and Ishino, 1998. *Knowledge-Driven Work*, Oxford University Press, London
- Daneshgari, P. 1998. "Technological and Economic Trends in Automotive Related Product Development and Manufacturing", *SAE Technical Paper Series 980744*, Detroit, MI
- Gilbert, S. M. 2004. "On Infrastructures for Resolving Novelty in Product Development: A View from the fast paced world of imaging and printing", Cambridge, MA, Massachusetts Institute of Technology, Thesis Paper
- Kleiner, A. and Roth G. L. 1997. "When Measurement Kills Learning", *Journal of Quality and Participation (November – December, Volume 20, no 5)*
- Kleiner, A. and Roth G. L. 1997. "Learning Histories: A New Tool for Turning Organizational Experience into Action", <http://ccs.mit.edu/lh/21cwp002.html>
- Leonard-Barton, Bowen, Clark, Holloway and Wheelwright. 1994. "How to Integrate Work and Deepen Expertise", Harvard, MA, *Harvard Business Review*, (September - October)
- Liker, J. K. 2004. *The Toyota Way: 14 Management Principles from the World's Greatest Manufacturer*, McGraw-Hill

- Maier, M. W. and Rechtin, E. 2002. *The Art of Systems Architecting 2nd Edition*, CRC Press, Boca Raton, Florida
- Marquis, D. G. and Straight, D. L. 1965. "Organizational Factors in Project Performance", Cambridge, MA, Massachusetts Institute of Technology, Sloan School of Management
- Merriam-Webster, 2003. *Merriman-Webster's Collegiate Dictionary 11th Edition*, Merriman-Webster Inc., Springfield, MA
- Morelli, M. D. and Eppinger S. D, et al. 1995. "Predicting Technical Communication in Product Development Organizations", *IEEE Transactions on Engineering Management (Volume 42, no 3)*, pp 215 – 222.
- Nonaka, I. and H. Takeuchi, 1995. *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press, London
- Roberts, E. B. and Berry, C. A. 1985. "Entering new businesses: Selecting strategies for success", *Sloan Management Review (Spring, vol. 26, no. 3)*
- Roberts, E. B. 1993. "Strategic Management of Technology: Global Benchmarking (Initial Report)", Cambridge, MA, Massachusetts Institute of Technology, Sloan School of Management
- Roberts, E. B. 2003. "Corporate Entrepreneurship: Strategies for Technology Planning and Business Development Lecture Notes"
- Roth, G. L. 1996. "Learning Histories: Using Documentation to Assess and Facilitate Organizational Learning", Cambridge, MA, Sloan School of Management
- Smith, B. C. 1998. "World Class Vehicle Launch Timing Part 1 – 6"
http://www.autofieldguide.com/articles/article_print.cfm
- Sobek, D. K, and Ward A. C. 1996. "Principles from Toyota's Set-Based Concurrent Engineering Process", *ASME Design Engineering Technical Conference*
- Sobek, D. K, Liker J.K, and Ward A. C 1998. "Another Look at How Toyota Integrates Product Development", Harvard, MA, *Harvard Business Review, (July – August)*, pp 36 – 49.
- Steward D. V. 1981. "The Design Structure System: A Method for Managing the Design of Complex Systems", *IEEE Transactions on Engineering Management (Volume 28, no 3)*, pp 71-74.
- Tyre, M. and von Hippel, E. 1993. "Locating Adaptive Learning: The Situated Nature of Adaptive Learning in Organizations", Cambridge, MA, Massachusetts Institute of Technology, Sloan School of Management

Utterback, J. M. 1976. "Innovation in industry and the diffusion of technology," *Science 18*: pp. 620 – 626.

<http://www.WordIQ.com>

<http://www.solonline.org>

APPENDICES

Table 1 – Is, Is Not

PROBLEM: Develop aesthetically pleasing parts that meet performance requirements and program timing.

	Is Not	Is
What:	<ul style="list-style-type: none"> ▪ Met timing plan ▪ Part that makes all parties 'happy' ▪ Independent of other parts, sub-systems 	<ul style="list-style-type: none"> ▪ Late ▪ Part gone through iterations, not perfect ▪ Dependant on other parts, sub-systems
Where:	Program Management	Studio, Body Engineering, Suppliers, Design Engineering, Electrical, Seats, Climate Control
Object:	Desired class A surface	Designed A class surface
Defect:	<ul style="list-style-type: none"> ▪ On time 	<ul style="list-style-type: none"> ▪ Late ▪ Translates into compressed tooling costs, \$\$
When:	At checkpoints 3 - 5	At checkpoint 5
Geographically, first seen:	Rare	Frequent, all programs

Table 2 -Error Proofing

Error definition is when any of the conditions necessary for successful processing are improper or absent. Cause -> Result Errors -> Defects

Steps	Description	Assessment
Step 1:	Identify and describe defect	Marginally acceptable pleasing parts that meet performance requirements and do not meet program timing
Step 2a:	Determine where defect is <i>discovered</i>	Defect 1: At checkpoint 5, and afterwards, since styling still wants to iterate Defect 2: Part does not meet performance requirements at prove out/verification Defect 3: Flagging of issue at prior milestones, checkpoints
Step 2b:	Determine <i>where</i> the defect is made	At checkpoints 1 – 3
Step 3:	Detail the current standard procedure	Program Kick off -> Checkpoint 1 -> Checkpoint 3 -> Checkpoint 4 -> Checkpoint 5
Step 4:	Identify deviations from standards	Defect 2: Part does not meet performance requirements at prove out/verification
Step 5:	Identify the Red Flag condition (s), where defect occurs	<Why?> Issue not identified at milestone checkpoint <Why?> Not all critical information available, understood, or given <Why ?> Changes design, appearance or variants OR Needs to be incorporated to see impact to requirements <Why ?> Iteration with styling to get approval, rework <Why ?> Repeat rework iterations for styling approval <Why ?> Something then to buy-off on
Step 6:	Identify the type of error proofing device type required to prevent the error or defect	Processing omissions, Processing errors Missing parts Adjustment measurement Dimension errors

COMMUNICATION SHEET

Description:	Joint Check Review		
Date:	November 10-11, 2002	Time:	9:30-17:00
Originator:	XX		
Distribution*:	Program N Japan NR3: * XX, *XX Program N Japan NR2: *XX, *XX Program N Japan NT8: *XX Program N North America: XX Program N Mexico: *XX Supplier L- JAPAN: *XX, *XX, *XX, *XX Supplier L - MEXICO: *XX, *XX, *XX, XX Supplier L - US: *XX, *XX, *XX, *XX, XX, *XX		

(* Indicates in attendance)

COMMUNICATION CONTENT

PARTS REVIEWED

<u>PART NUMBER</u>	<u>PART NAME</u>	<u>DESIGN LEVEL</u>	<u>DATE</u>
XX1	DASH SIDE TRIM, RH/LH		11/10/2002
XX5	REAR PILLAR TRIM, RH/LH		11/10/2002

MEETING OVERVIEW

- All bodyside parts reviewed were second shots. Supplier L intends to modify the parts as described / defined (including timing) in the Product Development Record (PDR) documentation. The purpose of this meeting was to review the open issues already established by Supplier L and to identify any new issues (from Program N's perspective).
- Supplier L provided gages and gage certifications for all parts. In addition Supplier L (US, Mexico, Japan) has conducted an internal review on the gages and compiled a first-draft PDR for each gage (8 total at this time).
- The final Joint check will take place on August 1, 2004 at Supplier L Build Center. All bodyside parts listed above and the respective gages will be available for review at that time.
- Three categories of PDRs were developed: design, tooling and gage issues. Design PDRs were generated from issues discovered during component-level inspection and full-vehicle (RBG / QVH) assembly. Any additional issues identified during the Joint check review will be documented using a PDR.
- PDRs were presented for all issues identified prior to the Joint check event. All new issues will be added to existing (open) PDRs, or a new PDR will be created. Additional detail can be found in the PDRs that specifically relates to the issue.

PDR REVIEW

DASH SIDE TRIM, RH/LH

	<u>DESIGN ISSUE</u>	<u>COUNTERMEASURE</u>	<u>STATUS</u>
1.)	Clip tower requires additional strength.	Add vertical rib from wall to base of doghouse.	Closed
2.)	Locator pins need additional strength.	Add gusset ribs & locator at base of pin.	Closed
3.)	Lower LH dash clip does not engage / interferes with carpet.	Under investigation (ribs, carpet thickness...); issue to be resolved by 7/1.	Open
4.)	Fit of welt attach hooks to A-B flange on RH part.	Under investigation; fit improved with welt attached.	Open
	<u>TOOLING ISSUE</u>	<u>COUNTERMEASURE</u>	<u>STATUS</u>
5.)	Flash on parts (doghouse / welt tabs).	Processing issues to be corrected for U3 part trial.	Open

COMMUNICATION SHEET

Description:		Joint Check Review		
Date:		November 10-11, 2002	Time:	9:30-17:00
6.)	Part sticking @ doghouse / ribs / tabs.	Remove all EDM from core side of tool; draw polish all ribs / lifters / slide features.	Open	
7.)	Clip holes do not match data; 5.0mm.	Clip holes changed to match data (4.5mm).	Closed	
8.)	Need part identification for U2 parts.	Part info added, per Program N standard.	Closed	
<i>GAGE ISSUE</i>		<i>COUNTERMEASURE</i>	<i>STATUS</i>	
9.)	Must use a step gage for individual part inspection (ex. a-a, T-102).	Step gages ordered 6/26/04 to support QP part measurement.	Closed	
10.)	All points must be indicated on CKFD and all Program N F & F points must be identified.	CKFD / Inspection Sheets updated by 6/28/04.	Open	
11.)	Update sections vs. checking fixture (include new sections)	CKFD / Inspection Sheets updated by 6/28/04	Open	
12.)	Establish measuring points for gage templates.	Gage updates complete to support U3 part trial.	Open	
13.)	The slider locations (A1, B2, two-way) have interference when the part is out from the gage.	Add lock for two slider locations and the two-way. Gage updates complete to support U3 part trial.	Open	
REAR PILLAR TRIM, RH/LH				
<i>DESIGN ISSUE</i>		<i>COUNTERMEASURE</i>	<i>STATUS</i>	
1.)	Locator pins need additional strength.	Add gusset ribs & locator at base of pin. Change verified on U2 parts (6/14/04).	Closed	
2.)	Ribs on platform (along clip tower) missing R1.	Add chamfer between clip tower & ribs. Change verified on U2 parts (6/14/04).	Closed	
3.)	Engagement of seat back fin (into rear pillar) is difficult due to deflection of rear pillar during installation.	Extend rear pillar flange to follow line of sheet metal (1-2mm stand-off). Fix verified on BUCK with hand-worked parts (6/20/04); will evaluate parts at U3 trial.	Open	
4.)	Inconsistent gap between rear pillar and p-shelf.	Under investigation. Will evaluate with U2-level parts (week of 6/31/04).	Open	
5.)	BSR on c-pillar (possible stand-off to S/M or interface to p-shelf).	Will evaluate during QP build. If condition can be duplicated, will investigate countermeasure at that time.	Open	
6.)	Pillar trim gaps to headliner.	Headliner working to improve stiffness (NDS level) via glass & adhesive reformulation. ST: will add foam to headliner for QP to remove gap.	Open	
<i>TOOLING ISSUE</i>		<i>COUNTERMEASURE</i>	<i>STATUS</i>	
5.)	Diagonal structural rib on back of part does not match data (should be constant cross-section).	Tool modified to reflect actual data. Fix verified during U2 part trial (6/15/04).	Closed	
6.)	Flash on lifters, HIC ribs & locators.	Processing issues to be resolved for U3 part trial.	Open	

COMMUNICATION SHEET

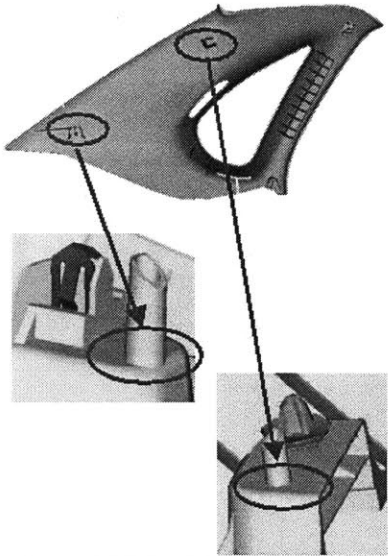
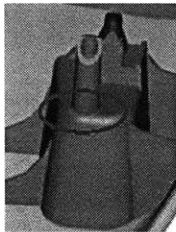
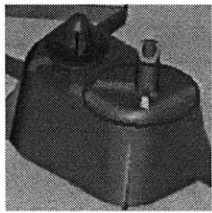
Description:	Joint Check Review		
Date:	November 10-11, 2002	Time:	9:30-17:00
7.)	Pin push on bottom of c-pillar.	U2 parts required mold release to eliminate pin push. Processing issues to be resolved for U3 (no release agent), all EDM removed from part and ribs to be polished.	Open
8.)	Need part identification for U2 parts.	Part info added, per Program N standard.	Closed
<i>GAGE ISSUE</i>		<i>COUNTERMEASURE</i>	<i>STATUS</i>
8.)	Problems with measurement below points (gap).	Cut taper gage to smaller size. Gages to be corrected to support U3 part trial.	Open
9.)	Review information for body simulation (at the rear of the pillar).	Verify gage matches data. Re-work gages if necessary. Corrections must be made to support U3 part trial.	Open
8.)	4-way locator made of material other than steel.	Material will be changed to steel. Gages to be corrected to support U3 part trial.	Open
GENERAL GAGE REQUESTS (PER PROGRAM N) – ALL GAGES (COMPLETE 7/14/04)			
ISSUE		CHAMPION(S)	
1.)	Certification reports must reflect build tolerance. Reports to be modified.	MM, B. TT	
2.)	All gages must have work instructions. Work instructions to be created and attached to gages.	MM, B. TT	
3.)	All gages must have specific clamping sequence identified & attached to gage. Sequence provided by gage supplier.	MM, B. TT	
4.)	Clarify what points need measuring on the gage, BMQRQ sheets & GD&T sheets. All points must be reviewed & corrected.	N. XX, B. TT, M. DD, MM	
5.)	GD&T sheets must be up-to-date (Supplier L US / Japan).	Supplier L US / Japan	
6.)	Verify no SPC requirements on gages. Confirm with Program N that data is not required.	N. XX	
7.)	Inspection sheets (BMQRQ) must match CKFD (BMQRQ) and GD&T (for datums). Location and labeled points must match & be identified on BMQRQ sheets. All gages to be reworked as needed.	N. XX, B. TT, M. DD, MM	
8.)	Add points on the CKFD / Inspection Sheets for the use of the templates.	B. TT	
9.)	Buy tools for measuring flushness.	M. BBI	
10.)	Templates must be supported on gages (like seat back finisher) and cannot move.	MM, B. TT	
11.)	All removable simulator blocks must have pins to align them to the fixture.	MM, B. TT	
<u>JOINT CHECK WRAP-UP</u>			
1.)	<u>ALL</u> gage fixes complete by U3 to support final Joint check (8/1/04 at Supplier L Build Center).		
2.)	Gage & BUCK and final Joint check location		
3.)	QP level parts from North America must be available at final Joint check.		
4.)	Q-Shelf vehicle number assumed to be equal to scuff trim color (measure equal to scuff).		
5.)	Overhead direction is required. Unknown as of review close (6/25/04).		
6.)	Vehicle check, during QP (all parts): Supplier L scheduled on 9/2/04 (9:15pm) - 9/3/04 (3:00pm).		
7.)	2 nd vehicle review at MSD, 9/20/04, 9:15am – 5:00pm.		
8.)	2 nd vehicle review at MSD (trunk trim only), 9/30/04, 1:45pm – 5:00pm.		
9.)	Any corrections to initial vehicle check parts, must have parts complete (with countermeasure) by: MRD: 10/9/04 – for North American parts to MSDNA 10/30/04 – for Asian parts to MSD		
10.)	Supplier L must send five (5) inspection parts to MSD for QP. In addition, one (1) measured set must be sent to MSD to support pilot jig review. “Gift set” must be Build Center for MSD to pick up, 8/23/04; MUST HAVE DATA also.		
11.)	Subsequent events will result from vehicle checks.		

COMMUNICATION SHEET

Description:		Joint Check Review			
Date:		November 10-11, 2002		Time: 9:30-17:00	
12.)	Supplier L to provide NN-san with a copy of North American-made part PDRs.				
13.)	Supplier L must complete BOQRQ capability proposal to verify what needs to be checked for QP.				
14.)	Awaiting decision of front kicking plate and rear kicking plate (re: integrated plastic vs. separate metal clip). If integrated clip is used, then only check fixture (component) data is required for capability study. If metal clip is used, vehicle-level data (BUCK) data is also required.				
15.)	Supplier L to provide OEM contact with copy of integrated clip retention agreement: 50% reduction after one (1) time on / off.				
16.)	Agree to fix rear kicking plate to rear seat back finisher by thickening the C/C part-to-part feature wall. Agreed to small sink in that area to fix part function.				
17.)	Include latest design level & average weight on all BMQRQ documents.				
18.)	Add boss at front of seat back finisher tab: 2mm gap to S/M (see PDR).				
19.)	Customer to be contacted by S. DD for integrated plastic clip / front kicking plate tryout				
Supplier Initial		Supplier Initial		Program N Initial	Program N Initial

BMQRQ - PROJECT DEVELOPMENT RECORD

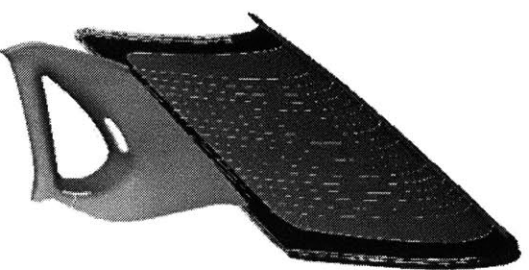
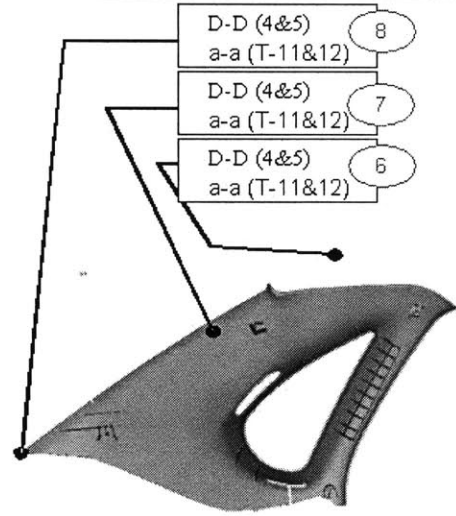
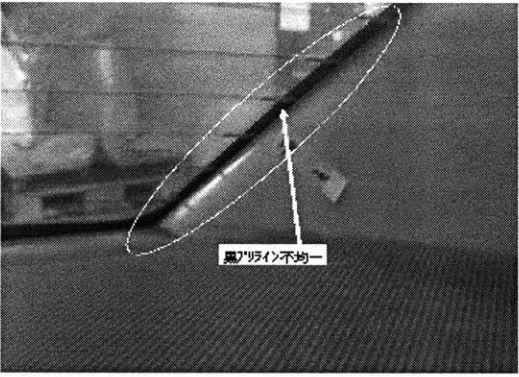
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Part Number: <i>XX1</i>	Part Name: <i>Rear Pillar Trim, RH/LH</i>	Tryout Location: <i>XX</i>	Issue Date: <i>01/01/2002</i>

No.	Detail	Countermeasure											
1.	<p>(A.) The locator pin does not have a radius at the doghouse interface; this design could cause a stress point to develop that results in the pin breaking off during assembly.</p> <p>(B.) The locator pin needs gusset ribs to provide stability during installation</p>	<p>Temporary:</p> <p>N/A</p>	<p>Permanent:</p> <p>(A.) Radius (R1) added at base of locator pin.</p> <p>(B.) Ribs added to locator pin in three locations.</p>										
Report No.													
VES #:													
CUS #:													
NTI #:													
ACM #:													
ECN/RFQ:													
22897													
Other:	<table border="1"> <tr> <td>Design Note</td> <td></td> <td>Design Note</td> <td><i>HU-9867</i></td> </tr> <tr> <td>Judgement</td> <td></td> <td>Judgement</td> <td><i>OK</i></td> </tr> <tr> <td>Date</td> <td></td> <td>Date</td> <td><i>7/29/2004 (QP)</i></td> </tr> </table>	Design Note		Design Note	<i>HU-9867</i>	Judgement		Judgement	<i>OK</i>	Date		Date	<i>7/29/2004 (QP)</i>
Design Note		Design Note	<i>HU-9867</i>										
Judgement		Judgement	<i>OK</i>										
Date		Date	<i>7/29/2004 (QP)</i>										
Raised By:	<i>M. DD</i>	Confirmation	<i>Off-tool</i>										
Date: <i>01/01/2002</i>	Build: <i>Tachiai</i>												

Build Event	Status	Build Event	Status	Build Event	Status	Build Event	Status	Build Event	Status	Build Event	Status	Build Event	Status
<i>Tachiai</i>	<i>Open</i>	<i>QP</i>	<i>Closed</i>	<i>QP (US)</i>		<i>RDW</i>		<i>QU2</i>		<i>QU3</i>		<i>TPQ</i>	

BMQRQ - PROJECT DEVELOPMENT RECORD

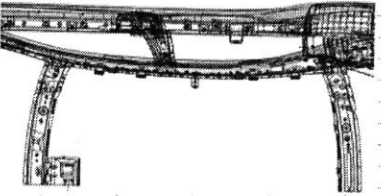
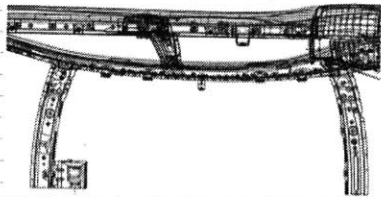
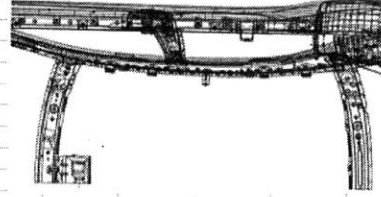
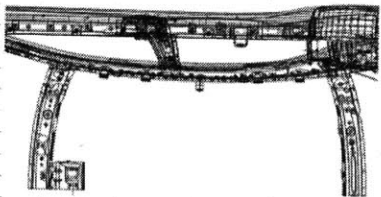
Supplier Name: <i>Supplier L</i>	Supplier Plant: <i>Mexico</i>	Supplier Code:	Issue Level: <i>01/04/00</i>
Part Number: <i>XX1</i>	Part Name: <i>Rear Pillar Trim, RH/LH</i>	Tryout Location: <i>XX</i>	Issue Date: <i>01/01/2002</i>

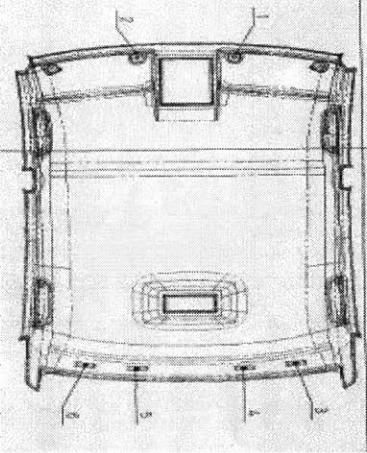
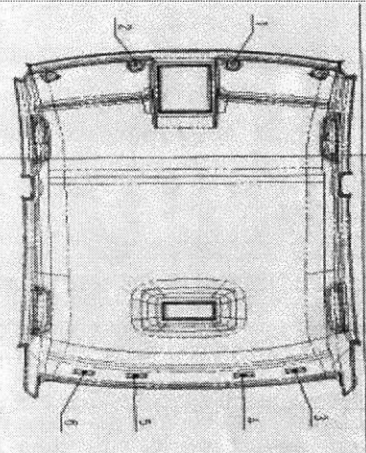
No.	Detail	Countermeasure														
5.	Rear pillar edge does not have consistent spacing to the blackout paint on the rear glass; appears wavy.	Temporary: Verified data (measured for S-Lot part submission) as: Point(s) #6, #7, #8: flush measurements are "NG." Will review RDW unit with later level parts known to be in spec.	Permanent: Will monitor during RDW build.													
Report No.	<div style="border: 1px solid black; padding: 5px; width: fit-content;"> REAR PLR TRIM not uniform with black print line </div> 		Final confirmation during build. Agreed eval unit was OK. 													
VES #: 59 & 65																
CUS #:																
NTI #:																
ACM #:																
ECN/RFQ:																
Other:				<table border="1"> <tr> <td>Design Note</td> <td><i>N/A</i></td> <td>Design Note</td> <td><i>N/A</i></td> </tr> <tr> <td>Judgement</td> <td><i>TBD</i></td> <td>Judgement</td> <td><i>OK</i></td> </tr> <tr> <td>Date</td> <td><i>11/7/2004 (RDW MRD)</i></td> <td>Date</td> <td><i>11/27/2004</i></td> </tr> </table>	Design Note	<i>N/A</i>	Design Note	<i>N/A</i>	Judgement	<i>TBD</i>	Judgement	<i>OK</i>	Date	<i>11/7/2004 (RDW MRD)</i>	Date	<i>11/27/2004</i>
Design Note				<i>N/A</i>	Design Note	<i>N/A</i>										
Judgement				<i>TBD</i>	Judgement	<i>OK</i>										
Date				<i>11/7/2004 (RDW MRD)</i>	Date	<i>11/27/2004</i>										
Raised By: <i>S. KK</i>	Confirmation															
Date: <i>01/01/2002</i> Build: <i>QP</i>																

Build Event	Status	Build Event	Status	Build Event	Status	Build Event	Status	Build Event	Status	Build Event	Status	Build Event	Status
Tachiai	<i>Open</i>	QP	<i>Open</i>	QP (US)		RDW		QU2		QU3		TPQ	

Decision Matrix

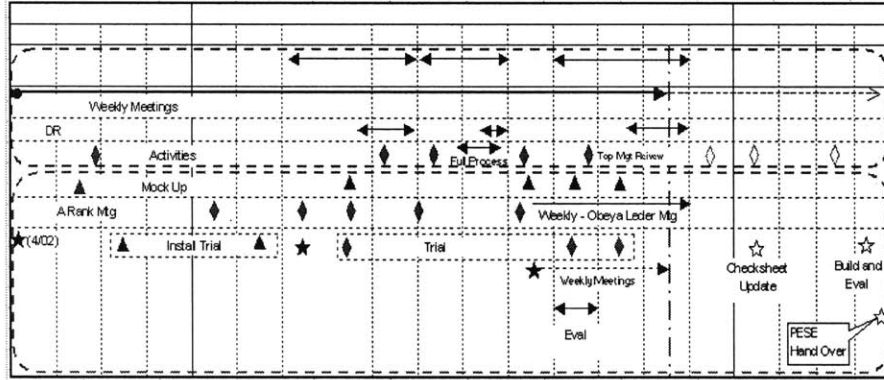
Problem:

No.	Sketch	Description	Ergonomics	Quality	Evaluation	Weight (g)	Cost	Mfg. Outlook	Comment
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2			○					○	
3			○					X	
4			△ X					X	

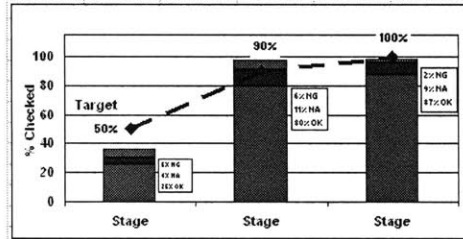
Decision Matrix -Headliner Study			
Option			
Schematic Drawing			
Density			
Mass			
Part Cost			
Process Cost (A)			
Total Cost			
Cost Difference		-	
Mass Difference		-	
Concerns	Design		
	Assembly		
	QE		
	PE		
Judge	Quality	△	○
	Performance	X	△
	Part Cost	○	△
	Mass	○	△
	Ergo	○	○
Overall Judgement			

A3 Example Interior Module Summary Report (Actual Info Removed)

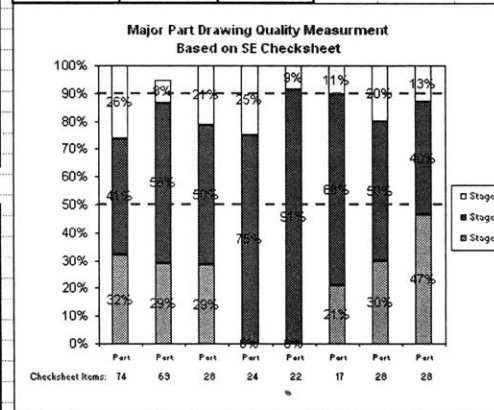
I. Overall Schedule



II. Drawing Quality Measurement



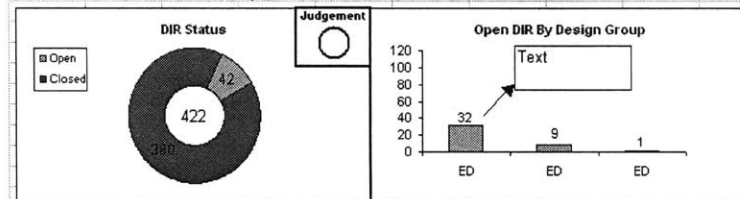
Checksheet Completion Status	99.8%	Judgement	<input type="radio"/>
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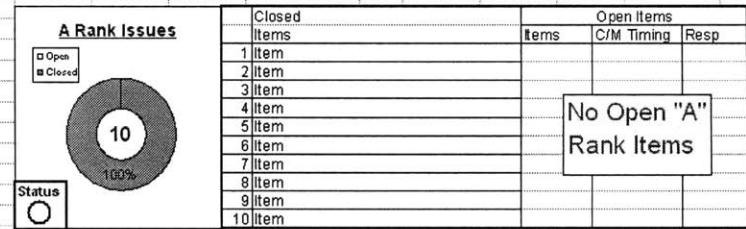
Gap Analysis Target Vs. Actual

Stage	<ul style="list-style-type: none"> - Unorganized/ Late distribution of data locations - No dwg data for carpet, scuff plates, and luggage area - Checksheet requirements were not utilized by Design - 90% Checksheet target was achieved overall
Stage	<ul style="list-style-type: none"> - Checksheet requirement were utilized by Design - Input from 3 step reviews from all groups - Reason for some major part not reaching 90% target changes not made to mod components Styling and structure changes - Triangle garnish to be rel with outside mirror not door trim
Stage	<ul style="list-style-type: none"> - Drawing has been delayed

III. DIR Status (All Interior Groups)



IV. A Rank Summary



A - Rank Item Resolution (Reflection)

Rank	Time To Resolve	Item	Cause	Reflection Point
(+)	2 Months	Item		-All involved groups attending mock up -Report quickly issued with group agreement
(-)	5 Months	Item	-Completely new structure -3 diff designs concepts for hinge structure -Diff members at each mock up	-Reduce concept ideas with more investigation and discussion -Keep same members for each mock up trial
(-)	8 Months	Item	-Indecisive Assy -Mulpt trials no results -Mgt involved late	- Raise up and discuss directly w/ upr mgt quicker -Output results report after each investigation

V. Module Reflections

Rank	Reflection	Countermeasure	Target
(-)	For activity was difficult to identify true issue with different data levels	Need to have good communication to get latest data for all area and on time	
(-)	Sometimes difficult to maintain ongoing issue resolution with due to mult activities & people	Designate one person over area to maintain consistency throughout issue resolution and project	
(-)	Some inconsistency on feedback methods at each stage	Need to have kick off meeting at each stage to set expectation and review schedules	
(+)	Beneficial to have design go and see activity at plant	Request groups for more go and see activity to help with issue resolution	
(+)	Mock ups and RP Parts are critical for problem resolution with project	Used many solve issues need to develop further to get fullest extent possible out of mock up	

VI. Future Concerns

Drawing Activity:	-Drawings on schedule - project all parts for
Item	- First time use of this structure in North America - Requires modification of installation equipment

VIII. Future Activity

Stage	- stage reflection with each group
Checksheet Update	- Need to add new 770N items to checksheet
Confirmation Vehicle	- Reconfirm A rank issue - Overall Interior fit and finish
Overall Judgement	<input type="radio"/>

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