The Role of Specifications and Contracts in Outsourced Product Development in the Automotive Industry

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This work is dedicated to my family and friends........

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ABSTRACT

Much attention has been paid to relationships between supplier and buyer firms, especially in the field of product development and in particular in the automotive industry. There has been a growing debate on the need to increase the responsibilities for suppliers and have a win-win relationship with them instead of an adversarial relationship. Research has been extensive, dealing with issues like location of suppliers, just in time, tiering of suppliers, etc., although little attention has been paid to the issue of specifications and contracts which are an important part of the product development process. The specification flow between the buyer and suppliers is necessary in order to obtain the product. Specifications could be validated[1] with the help of written contracts and thus can be seen as an important part of the contracts. The objective of the study is to understand the role of specifications and contracts in these companies and thus contribute to knowledge and the understanding of practitioners. One automotive OEM located in Europe was used for the case study. One aircraft OEM, also located in Europe, was used for supplementary data collection. In-depth interviews in five first-tier suppliers, and an open ended questionnaire survey (internal and external) have been used to provide complementary perspectives.

The research[2] is guided by a qualitative inductive approach and is aimed at developing ideas grounded in field observations. Strauss & Corbin's (1990) method for coding qualitative data has been followed in order to model the role of specifications and contracts. Data was gathered through semi-structured interviews with various managers in the OEMs and supplier companies, participant and direct observation, internal documents, and questionnaires.

Specifications were identified to have a role in guiding outsourcing decisions, function as a means of communication, help decide the time of involvement of the suppliers, help differentiate suppliers, create visions for suppliers and help provide competitive advantage. Contracts were identified to have a role in reaching agreements for continuing supply and help assist in the validation of specifications.

Keywords: Product Development Management, Buyer–Supplier Relationships, Specifications, Contracts, Validation

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[1] The term "validate" used throughout this thesis does not mean pre-approval before production but acceptance of performance of the supplier (through validation parameters contained in a contract) to deliver to specification during the development/production of the final product.

[2] Certain portions of this thesis have already been published/accepted for publication in Business Horizons, Journal of Product Innovation Management, Journal of Supply Chain Management, Purchasing Today and European Management Journal.

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1. INTRODUCTION TO THE DISSERTATION - PROBLEM AREAS AND PERSPECTIVES

1.1 Introduction

Firms are today more actively involving suppliers in their integrated development processes and have identified suppliers as a source of competitive advantage (Cusumano & Takeishi, 1991; Nishigushi& Beaudet, 1998; Quinn & Hilmer, 1994; Richardson, 1993). That means that there is room for development and identification of factors that could help sustain/improve the relationship between the buyer and the supplier in outsourced product development. There are various factors that one could look into when trying to improve/sustain the buyer-supplier relation such as JIT, location of suppliers, trust, specialised investments, specifications and contracts (Lamming, 1993; Cusumano & Takeishi, 1991; Harris, 1998; Sako, 1992). With the exception of specifications and contracts, the literature dealing with buyer-supplier relationships is very rich. Would this suggest that specifications and contracts are not important? Initial exploratory interviews with industry experts and practitioners in the automotive industry suggest the contrary. Supported by few existing references (Smith & Reinartsen, 1991; Kaulio, 1996; Harris, 1998), this research sets out to explore the role of specifications and contracts in product development. The industry in which the specifications and contracts will be explored is the automotive industry, while supplementary data regarding contracts will be obtained from the aerospace industry. In Europe/North America, the automobile industry was the first to encounter the phenomenon of "Japanisation". The industry had to adopt the Japanese practices in order to survive. Overall, one could say that the auto industry led the way in establishing work practices in other industries. Hence, a study of the auto industry[3] is quite important, as it will also lead the way for improvements in other industries.

The exploratory nature of this research calls for a qualitative research methodology. In view of the weak body of literature in the areas of specifications and contracts, the main objective will be the conceptual development and extension of existing theoretical frameworks for analysing buyer-supplier relationships in outsourced product development in the automotive industry.

[3] Please refer to appendix 4 for an overview of the automotive industry.

The following working definitions of central notions are presented at this stage. These definitions will be further discussed and enriched from the literature review and as an end result of this thesis itself.

Specification

The final written document (called the document which includes all the sub-documents) and the process of arriving at the final written document (called as specifying) together add up to the "Specification". This thesis will use the double meaning defined above, as without the process there will be no document. Kaulio (1996) is the only author to refer to the double meaning of the specification while authors such as Smith & Reinartsen (1989) refer to the specification as a written document alone assuming the specifying process to be tacit and present.

Contracts

Contracts have been seen as a legal document in current research. The validating role or the ability of contracts to check that the specifications have been satisfied has been less researched (Harris, 1998). A central working hypothesis is that contracts could assist in the validation of specifications. It is this validation role and not the general legal role in product development that will be explored in this thesis. The term "validate" used throughout this thesis is not pre-approval before production but acceptance of performance of the supplier (through validation elements contained in a contract) to deliver to specification during the development/production of the final product. Contracts referred to in this thesis are those that are exchanged between a buyer and supplier/s and not internal contracts that are articulated within a firm.

This chapter will commence with a discussion of the motivation behind this research. This will be followed by an explanation of the modelling of the development process and finally, by a discussion on specifications and contracts. An explanation of the term "role", the research problems and the research perspectives will also be introduced in this chapter.

1.2 Setting the scene: The motivation behind the research

In order to grasp the essence of specifications and contracts, one must go back in time to the era of craftsmanship and observe the changing role of specifications and contracts in the automotive industry. This will also help the reader to understand the relevance of the topic. I will first discuss the evolution of work practices from craftsmanship to lean production, then study the varying demands on the services of the suppliers in the work practices discussed above, and finally analyse the changing role of specifications and contracts in these eras.

1.2.1 Evolution of the automotive industry and the changing role of suppliers

In the era of craftsmanship there was a direct link between the customer and the shop floor personnel. A classic example of an automotive firm from the craftsmanship era is P&L (Womack et al., 1990) which was the leading automotive company in 1894. There were no car dealers and no standards in the late 1800s. Each car was tailored to individual customers. Since there was no standardisation, there was a need for rework such as in filing and shaping parts so as to make them fit. There were a number of individual sub-contractors working directly in the P&L[4] plant (Womack et al., 1990). There were obvious problems with the craftsmanship style due to the following reasons:

- High production costs
- Reliability problems as no two cars were alike
- An inability on the part of the independent sub-contractors to innovate.

The problems inherent to the craftsmanship era (in automobiles) gave rise to mass production. In the beginning of mass production there was "Fordism" which was developed by Henry Ford (manufacturer of the model-T car). Ford started by using standard gauges, and thus standardising the work procedures so that the components could be interchangeable (Womack et al., 1990). Ford also pulled everything in house, manufacturing everything that was required to make an automobile under one roof. The parts were standard and thus, did not require skilled personnel, unlike

[4] Please refer to appendix 6 for a glossary of terms and abbreviations.

during the craftsmanship era. During the 1950s, Ford outsourced components that were previously made in-house. The outsourcing was price-based and the supplier with the lowest quote got the orders. Low profit margins meant that the suppliers could not invest in research and development and thus innovate for the customer. The pioneer continuous flow system developed by Ford – steel and rubber came into the factory and ready-to-drive cars came out (Krafcik, 1988)-had to be complemented by a number of managerial principles before it was possible to set up a traditional model of mass production. Though Ford was successful, he did not provide the customers with variety. Alfred, P. Sloan of General Motors did.

Womack et al. (1990) and Berggren (1992) emphasise the importance of the development at General Motors during the 1920s under Alfred Sloan. Sloan provided variety to the customer and also created independent profit centres within the General Motors group to make components. Sloan developed stable sources for outside funding, created new professions within marketing and finance to complement the engineering professions etc. In the 1980s, General Motors tried to outsource many components that were made by the in-house profit centres, but since this was met with internal resistance, the outsourcing percentage remained quite small and was still price-based. Sloan's ideas combined with Fords manufacturing system (technology) and Taylor's scientific management (organisation) was instrumental in developing the traditional mass production system (Berggren, 1992).

Over time, each firm goes through significant changes in its strategy, deep crises and/or strong growth, and changes in its geographical penetration (market and manufacturing investments in new regions, or withdrawals) (Boyer & Freyssenet, 1995). The specific trajectory of the Japanese and in particular, Toyota, gave rise to the lean production system. Krafcik (1988) was the first to coin the name "lean production". In the lean production paradigm, independent suppliers are involved to a large extent and the OEM[5] restricts itself to vital systems or the whole product and in this case the car (Lamming, 1993). Large numbers of components and systems may be outsourced according to the lean production paradigm. Womack & Jones (1994) summarise the main elements of the lean enterprise as follows:

[5] OEM stands for Original Equipment Manufacturer. Some examples of OEMs are General Motors, Ford, Electrolux, etc.

- Focusing on a limited number of activities within each firm
- Strong collaborative ties with clear agreements on target costing
- Joint definition on levels of process performance
- Joint definition on rate of continuous improvement and cost reduction
- Consistent accounting systems

- A well-defined formula for splitting the losses and gains. In the lean enterprise, each participant adds value to the production chain.
- Reduction of waste (muda) that gives the potential for significant performance improvement.
- Rotation of middle and senior managers between the company operations; suppliers and foreign operations are the central elements of this new industrial structure (Womack & Jones, 1994)

It will be observed from the above that the role of the supplier has changed. In the craftsmanship era, the role of the supplier was to take charge of making parts and components that were fitted together by the main assembler. Sloan provided variety for the customer in the mass production era and set up independent profit centres within the General Motors group though once again there was limited outsourcing that was price based. In the era of lean production, the supplier involvement shot up from no or little involvement to increased involvement and responsibility.[6] Suppliers are responsible for entire systems and sub-systems. In the current era of lean, supplier management is considered to be very important and many manufacturers are concentrating on their core competencies, leaving the rest to the suppliers (Leenders et al., 1994).

[6] It does not mean that all suppliers in the lean era will be given system responsibility. The trend is to help all suppliers to reach the level where they can handle systems and sub-systems.

1.2.2 Evolution of the role of specifications and contracts

It has been observed that the role of the supplier has changed from the craftsmanship era to the lean production era. The changing roles of suppliers have obvious implications for the specifications. This is because the more involved the supplier is, in terms of time and complexity of the systems, the more he will presumably be involved in the specifications.

The specifications in the case of craftsmanship were very loose as the goods arriving at P&L were described to have "approximate specifications"[7] (Womack et al., 1990). General Motors had well-defined specifications,[8] as otherwise it would have been hard to estimate the lowest cost during the bidding process for the part in question. In cases where the specifications were not well defined, General Motors suffered losses[9] as the suppliers could exploit them, i.e., by charging money for changes in specifications. In lean production, since the supplier involvement is probably the highest as compared to all the other eras, the specifications would require joint involvement. Hence, the role of specifications has been changing from a loose specification in the craftsmanship era, to a tight specification, and finally to a joint specification (where both the OEM and the suppliers collaborate in the writing of the specification). There could be problems with each and this was quite evident considering the losses in the craftsmanship era and the mass production era (Womack et al., 1990).

The changing role of specifications has also been supplemented by a changing role in contracts. Contracts in this context are there to help validate the specifications. Contracts are increasingly growing in importance as outsourcing begins to grow as an

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[7] A specification in the craftsmanship era could have been as follows: Make a steering wheel with the steering rod to fit in a hole of diameter 15 cms.

[8] General Motors had drawings for most of the parts or at least specifications that were presumed to be complete in all respects. Source: Interviews with 6 General Motors Executives, in Detroit, USA, (March, 1998) based on observations of archival documents by the executives to maintain confidentiality. The big GM family at that time included its internal divisions such as Delphi and sourcing is the term used to reflect buying by the GM family and not purchases made between and from internal divisions.

[9] GM was making losses among many of its divisions as a result of loose specifications. This was one of the reasons for the abrupt departure of Billy Durant. Source: (History of General Motors, Workbook Companion for the "The Chairmans Perspective: General Motors Yesterday, Today and Tomorrow", November 1999, Detroit)

important strategy in organisations (Harris et al., 1998). Since, in lean production the degree of outsourcing[10] is perhaps the highest, the importance of the contract, as a validating mechanism will probably be significant. This is a proposition, which has not yet been proven, and it is not the aim of this thesis to prove this proposition either.

In sum, it may be observed that the roles of specifications and contracts become important when suppliers are involved. When suppliers are involved in the development process, the specifications are mostly of the joint type. The specifications tend to change from a one-shot communication to the supplier about demands to a two-way communication vehicle. In the case of contracts, the role could be observed to be changing from one based only on legalities to an important tool for validating specifications, (which includes the legal aspects as well). But there are several questions that arise. Do all the suppliers need to be involved in the joint specification? Do both the suppliers and the OEMs understand specifications in the same way? How are contracts established? How are they structured? etc. In order to answer these questions, it is important to understand the roles of specifications and contracts. Since the role of specifications and contracts has changed over time, this thesis will take a look at the current role of specifications and contracts.

1.3 Modelling the development process

Clark & Fujimto (1991) identify four major product development stages, namely, concept generation, product planning, product engineering and process engineering. Product planning translates the product concept into product specifications while product engineering translates specifications into detailed designs (Clark & Fujimoto, 1991). If the specifications are not correct, then the design will be inconsistent and thus lead to losses. Raia (1989), who comments that sixty to eighty percent of a product's cost can be traced to the design stage, confirms this point. I will consider an example to illustrate the above. If a part is given to a supplier for manufacture and it is not possible to manufacture it, then the OEM has to go back to the product planning stage and thus develop new/modified specifications. This would mean increasing the number of iterations and rework, which would cost money and time. Hence,

[10] This includes complexity of the parts, number of parts and the value of the parts outsourced.

understanding the role of specifications at the design stage itself would lead to savings in time and money.

OEM firms are giving increasing responsibility to their suppliers and encouraging them to get involved early in the product development process, according to various authors, for example, Kamath & Liker (1994), Clark & Fujimoto (1991), and Lamming (1993). The increasing responsibility may need to be channelled. In order to be able to outsource, a company needs to consider its entire product realisation process for a typical manufactured product (Fine & Whitney, 1996). This implies that an integrated specification[11] is necessary in order to gain the full benefits of outsourcing. They also comment on the fact that viable products are only possible if there is a good process and decomposition of the specifications. Involving the suppliers in the internal product development process could help companies achieve a strategic advantage (Schilling & Hill, 1998). Asmus & Griffin (1993) suggest that some of the big diverse companies (in products) like Toyota, Bose, Xerox, etc. have developed ways of involving suppliers in their product development process. As a result of the supplier involvement, they have been able to slash development times by as much as 40%, increase inventory turns from six to over fifty a year, and reduce the cost of purchased materials by between 15 and 35%. The theoretical rationale for an outsourcing strategy is provided by the core capability concept (Wernerfelt, 1984; Prahalad & Hamel, 1990; Leonard-Barton, 1992), elucidates Dyer (1996). In his studies of Nissan, Toyota, General Motors, Ford, Chrysler, and a sample of 152 of their suppliers (half of which were their closest partners, and the other half were their most typical arm's length suppliers), Dyer (1996), confirms that there is a positive relationship between supply chain asset specificity (technology, skills, capabilities), and performance (quality, cycle time, inventory cost, and profitability).

In the development process there are several roles that the specifications and contracts could fulfil. Before examining the roles that specifications and contracts could play, I would need to explain the terms "specification" and "contracts" in more detail.

[11] An integrated specification refers to a specification that is jointly developed between the buyer and the supplier.

1.3.1 Understanding specifications

During the product development process there are various activities that take place between the buyer and supplier, for example, joint testing, CAD data exchange, joint operational design, etc. Specifications are also exchanged between the buyer and the supplier. Specifications have been defined in a number of different ways. In order to understand the actual term specifications, I would need to explain the term design.

Vincenti (1990) describes the term design[12] and takes it to mean two things, namely the contents of a set of plans and the process by which these plans are produced. A set of plans for the product is equivalent to the written description of products (Smith & Reinartsen, 1991) and may be seen as a narrow definition of specification. Specification could also correspond to the process of producing the plans (Kaulio, 1996). This may be seen as a broad-based definition of specification. In other words, the broad-based definition of specifications includes not only the process of arriving at the specification, but also encompasses the document called the specification (Kaulio, 1996).

Specifications could also be seen as representing two different perspectives, namely the commissioning perspective and the mediating perspective (Kaulio[13], 1996). In the commissioning perspective, there is one-way communication and the contents of the specifications are essentially ready and simply have to be worked on. In the mediating perspective, the specification is a forum for dialogue and thus, the specification is created by the joint effort of the different actors in the development process. Kaulio (1996) further comments that the commissioning perspective corresponds to the narrow definition of specifications, while the mediating perspective corresponds to the broad-based definition of specifications.

It is difficult to comment on the superiority of the narrow-based definition or the broad-based definition. Even in the narrow definition, the process is present because without the process there will be no specification. Essentially this discussion indicates that there are two processes involved. The first is the process of getting to a

[12] The term design is used to refer to product development
[13] Kaulio (1996) is the only reference that discusses the double nature of specifications. There is no other reference to the double nature of specifications.

final specification document, and the next is to execute the contents of the specification document and to realise the product. For the purposes of this thesis, I will use the following definitions of specification (Figure 1-1). The specifying process is defined as the process involved in getting to the final written document. This is done by iterating and creating a number of draft documents (through sub-processes). Specifications (the final document and the specifying process) is the focus of this study and all other parameters lying outside the established framework will not be examined.

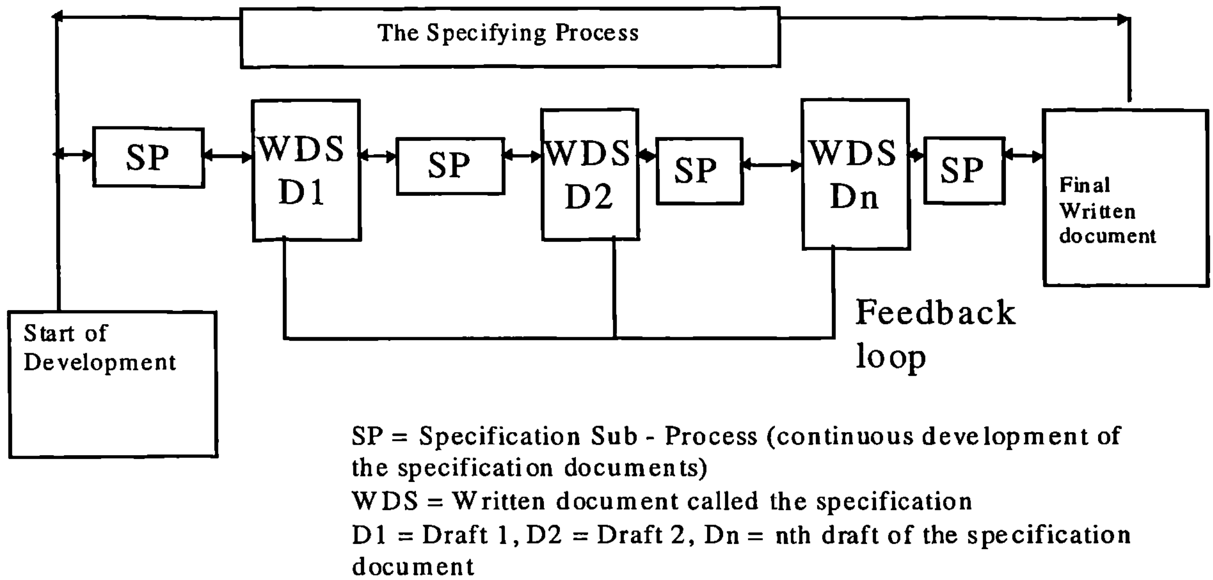

Figure 1-1, The view of specification for this research

The specifications are a means of conducting dialogue in the development process between both internal and external actors. They assist in co-ordination and integration of the design activities (Kaulio, 1996). The creation of interdependent tasks linked to each other and performed by specialised participants brings a need for co-ordination (Karlson, 1994). If the specifications were falsely interpreted by the supplier or the buyer due to a faulty process, the output would be chaotic. This means that the specifications may have to consider both the internal process of the supplier/buyer as well as the external process (the patterns of specification interaction between the buyer and the supplier). Imai et al. (1985) comment that information is a key resource and is of utmost importance in the new product development process. In outsourced product development, the buyer and the supplier each deal with a separate part of the environment and these tasks need to be linked to each other (Lawrence & Lorsch, 1967), thereby necessitating a high degree of co-ordination between the buyer and the supplier and thus on the information flow. This means that the flow of information between and within processes is very crucial for the success of the product development process and is a vital component for the survival of the product development process as a whole. In other words, no information flow would mean no co-ordination and thus the new product development process would be affected.

The specifications have a role to play both in contractual and non-contractual situations (Kaulio, 1996). Since in non-contractual situations the work is essentially done in-house but as this thesis is about outsourced product development, data collection and analysis will be limited to contractual situations, which are concerned with outsourced product development. The research question on specifications deals with the process of arriving at the written document called the specification and also with the written document itself. The research question on contracts is concerned with the content of the contracts that could aid the validation of the specifications. Finally, it may be concluded that specifications act as the trigger for the different activities that encompass the development process.

Contractual situations have been summarised by Teece (1987) as follows:

- The suppliers/distributors/manufacturers should be engaged in contractual situations only when the complementary assets to the part in question are not specialised. If the supplier has the specialised complementary assets, then the OEM could be putting itself at risk.

- If there are complementary specialised assets, then the OEM should check for the appropriability[14] regime. In a high appropriability regime, the technology is foolproof and the competitors are not able to copy the technology.
- In a case where the appropriability is weak, then the supplier may not be engaged in a contractual situation and instead the OEM should check whether the specialised assets to the part in question are critical. If the specialised assets are critical, the OEM should not outsource the part as it could be putting itself at risk and instead check for its cash position.
- If the cash position is not good, then the supplier should be engaged in a contractual situation, otherwise the OEM should check for whether the competitors/suppliers are better positioned.
- If the competitors/suppliers are better positioned, then it may be wise to engage them in a contractual situation.

The above discussion is very general and not specific to the suppliers, though it may help in understanding when to engage a supplier in a contractual situation. If the suppliers are the best at what they do, and it would take a lot of resources to catch up with them, then it may be wise to engage them in a contractual situation. If the cash position of the OEM is not sufficient for integration,[15] then it also may be wise to engage the suppliers in a contractual situation. If the specialised assets are critical for the OEM, then it may be putting itself at risk by getting the supplier into a contractual situation. But not all the OEMs are able to be the best in all the technologies[16] and instead prefer to concentrate on overall vehicle integration (Dyer, 1996). As a consequence suppliers are being made increasingly responsible for complex systems (Dyer, 1996; McDuffy & Helper, 1997). Hence, if the contractual situation is unavoidable, then there may be a need for explicit contractual elements that help validate the specifications. In the automotive industry, the suppliers are sometimes given overall vehicle integration responsibility albeit infrequently. This is because the interfaces between the different parts have a very weak appropriability, but that may not mean that the suppliers are not engaged in contractual situations to make parts that

[14] The appropriability regime signifies the extent to which the practicalities of the environment will allow a firm to retain competitive advantage from control over the process (Pisano et al, 1988).
[15] This means that the OEM would make the parts on its own. It could mean both backward and forward integration.
[16] The OEMs cannot concentrate on all the parts in the car.

do not weaken the overall product appropriability. Lastly, complementary specialised assets form a sense of mutual dependency between the buyer and the supplier (Teece, 1986). However, in order to avoid situations where the supplier might disrupt the competitiveness of the OEM, there is a need to confirm that the specifications are satisfied. The message from the above section is that the specifications must be validated in some way.

1.3.2 Understanding written contracts

Contracts have no formal definition, according to the law (Thorpe et al, 1996), which can seem very surprising. One definition of contracts offered by Thorpe et al (1996) is "an agreement, which the parties intend to be legally binding". This definition is also shared by Llewellyn (1931), who states that contracts are "a framework which almost never accurately indicates real working relations, but which affords a rough indication around which such relations vary, an occasional guide in cases of doubt, and a norm of ultimate appeal when the relations cease in fact to work". Keith (1931) elucidates that contracts are a species of agreement that creates between the parties a legal obligation. The legal obligation that contracts offer is a common theme in all the above definitions. This legal obligation according to Thorpe et al (1996) cannot be transferred to anyone who is not a party to the contract. Parallel to the present research, the legal obligation is considered to exist between the buyer and the supplier.

The content of contracts is hard to understand and individuals not used to dealing with contracts will often abandon the attempt, baffled by long, tortuous statements, and numerous cross references (Thorpe et al, 1996). They further state that commercial contracts will have been drafted by a lawyer. This means that since the lawyers will use words in a legal sense, one will need to recognise these words in order to understand a formal contract. This has also been expressed by Keith (1931), who elucidates that the "terms of a contract are seldom fully expressed in the actual instrument, and to the express terms legal science adds implied terms, which are assumed to accord with what would have been agreed to by the parties, had the contingencies in question presented themselves to their minds when they were engaged in the making of their agreement". A contract as described above generally includes all the legal obligations. In the relationship between the buyer and the supplier the latter is expected to satisfy the specifications given by the former. However, the presence of the legal obligations alone do not ensure that the supplier has understood the specifications, least the contents of the contract as they are hard to understand.

The contents of the contract can include many implicit terms (Keith, 1931) that could ensure the satisfaction of the specifications but not understood by the supplier. Hence, using validation elements to make the suppliers understand the specifications can be beneficial in satisfying the specifications. This can be made a part of the contracts along with the legal obligations. The validation elements can be seen as aiding the understanding of the legal obligations. I will not discuss the legal obligations as it is outside the purpose of this thesis but rather concentrate of the role of contracts as validating mechanisms in order to satisfy the specifications and thus, the legal obligations.

Specification flows between the buyer and supplier may need to be channelled or controlled. OEM firms do not rely on the suppliers to deliver a product, but instead on their ability to take over design, styling, development, component sourcing, cost and weight management, quality, manufacturing, etc. (Ponticel, 1996). This also includes delivery of ready systems and modules to the plants for installation. 1st-tier suppliers are increasingly under pressure to become integrators, designers and assemblers of the 2nd-tier suppliers and so on (Lamming, 1993[17]). This would mean creative thinking on the part of the suppliers, being more focused and stronger in their core competencies. All of these are new demands on the suppliers and hence there is a need for confirming whether or not these demands can be fulfilled. Cooper (1975) and Beecham (1996) articulate that the contracts can encompass negotiations such as results to be delivered, industry demands, etc. These negotiations can be seen as a way of confirming that the supplier can deliver what has been promised. However, no explicit link is made between the negotiation criteria and the specification, and nor the content of the contract discussed in order to aid the process of specification validation in literature. There is also no indication as to when these negotiations can be

[17] Evidence of this is slowly emerging from the automotive industry. See Buchholz, K., July 1997, Tier 1 suppliers speak on testing and validation, Automotive Engineering

conducted i.e. at the start of the business or during the business. However, an important point emerges i.e., contracts could be used as a mechanism to assist in the validation of the specification.

The validation aspect becomes all the more important if buyers and suppliers have different perceptions of their relationship (Arkader & Fleury, 1998). Validation could certainly help narrow the gap between these different perceptions by allowing the articulated demands to be checked for completeness. Newer demands require newer ways of working and this would in turn demand a new breed of validation mechanisms to ensure that the demands are being fulfilled. Written contracts could form a guiding or controlling mechanism in product development as they may help verify that the suppliers can meet the specifications. They could help play a major role in incorporating quality into the specifications and thus, into the final product by validating that the suppliers perform as required. There are other types of contracts such as verbal, simple, speciality contracts, etc. (Major & Taylor, 1996). However, these contracts cannot assist in validation to the same extant as written contracts. This is because the written contracts may have many validation criteria that are written down and are explicit. In the case of a verbal contract, the validation elements are not explicit and, thus, the OEM or the suppliers may misinterpret/forget the validation parameters. Since the research question limits itself to the validation aspect with respect to specifications, the literature review in the area of contracts must thus be limited to validation as well. In validating the specifications, it is important to cross check that specification parameters are being fulfilled by having a content list. While the content of the contract is important, it cannot be changed all the time as this will only lead to confusion.

1.4 The Notion of Roles in Product Development

Roles have been defined as "evaluative standards employed in assessing the behaviour of occupants of specific social positions" (Davis, 1949). The location within a system of social relationships can be defined as a social position.

This means that both the buyer and the supplier have specific social positions[18]. For example, the supplier may be expected to deliver components, while the OEM may be expected to assemble the entire product such as the car. There are certain expectations from the buyer and the supplier as to their behaviour which could be seen as roles. This thesis is dealing with outsourced product development and hence it is important to study the roles that have been seen as characteristic of product development. Then it will be useful to study the roles that are specific to specifications and contracts.

Roberts & Fusfeld (1981) indicate that five roles critical to innovation must be performed in product development teams within companies. These roles are as follows:

- Idea generating
- Championing
- Project - leading
- Gate-keeping, and
- Coaching.

These roles have to be performed by individuals working together with the firm on the product development projects. Each role has a specific purpose, which is as follows (Roberts & Fusfeld, 1981):

- In the idea-generating role, the purpose is to analyse and synthesise information about markets, technologies, approaches and procedures, and to generate ideas about new products and ideas or solutions to challenging technical problems.
- In the championing role, the purpose is to propose, push and demonstrate new technical ideas for formal management approval.
- In the project-leading role, the purpose is to plan and co-ordinate the diverse set of activities and people involved in moving a demonstrated idea into practise.
- In the gate-keeping role, the purpose is to collect challenging and important information about changes in the internal and external environment like developments in new technologies, markets, etc.

[18] The buyer and supplier may play a variety of roles, even simultaneously.

- In the coaching/sponsoring role, the purpose is to guide the less experienced personnel in their critical roles and to give behind-the-scene support.

The above discussion suggests that there are different roles, which could be performed by individuals in an organisation. However, the roles are internally focussed as they are within a company. In outsourced product development there are two firms involved, the buyer and the supplier. Thus it is questionable whether these roles may be applied in outsourced product development. If they are applicable, then are they to be performed by the buyer or the supplier or both? Roberts & Fusfeld (1981) essentially say that the product development roles are performed internally within a firm and in this case within the buyer. Therefore, it would be meaningful to discuss whether the supplier could perform these roles. Since this thesis is limited to the discussion of specifications and contracts, the discussion should centre on whether these roles could be applicable to the specifications that are worked on between the buyer and supplier in varying degrees of collaboration.

The suppliers may be involved in pushing ideas forward to the OEMs (championing role), leading projects[19] (project leading role), collecting ideas about the markets, technology etc. (gate keeping role) and coaching both the OEM and their own staff (coach). This essentially shows that both the buyer and the supplier could carry out the product development roles. If both the suppliers and the OEM could execute these roles, then would it be possible that the "written document called the specification" and the process to obtain it may also encompass some of these roles or at least act as vehicles to support these roles? I will explore whether some of the above-mentioned roles may be performed by specifications.

- Specifications could perform the role of acting as a vehicle where ideas are collected and also where ideas are generated. After reading the specification, designers could get ideas and when they compile their ideas into the specifications, this could form the basis for others involved in the development to generate ideas.

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[19] The supplier could take charge of developing, manufacturing and integrating a complex sub-system into the car.

- The specification could also act as a vehicle in facilitating the gate-keeping role. Specifications allow the designers to check and cross check whether the latest technologies are used and whether they are necessary in the first place or not. They also provide the basis for a forum where discussions could be held as to the missing parameters etc. The specifications could also facilitate the gate-keeping role by demonstrating the inter-connections between a diverse set of activities.
- The specifications could act as tools to support the roles of project leading, championing or coaching. The individuals could use the specifications as tools in their coaching, championing and project leading roles.

1.5 The Role of Specifications and Contracts

I will examine certain roles that have been seen as characteristic of the specification. Kaulio (1996) identifies four roles that specifications may play in the development process. They are the role of knowledge gathering, the role of market investigation, the role of analytic synthesis, and finally, the contractual role. In the knowledge-gathering role, the knowledge content of the specification increases as different individuals involved in the development share ideas and try to brainstorm thus leading to solutions that could be prototyped. In the market investigation role, the specification could function as a market research instrument. The specification content could reflect market needs as well as whether or not the technical solutions developed by the company have any market acceptance. In the analytic role, the specification contents are analysed, trade-offs are made and the contents essentially converge. In the contractual role, the specification is handed over and it essentially directs the design process.

I will now look at how the term role has been used in other contexts. Axelsson & Håkansson (1984) have stated that purchasing has three roles, namely a rationalisation role, a structure role, and a developmental role. The rationalisation role is with reference to the role that purchasing plays in reducing overall costs (such as logistics, direct material costs, indirect material costs, internal production costs etc. (Axelsson & Laage Hellman, 1991). In the structure role, purchasing is concerned with the supplier structure that encompasses the firm. In doing so, purchasing looks into the number of suppliers, screens suppliers, etc. Finally, in the developmental role, purchasing is concerned with the development of the suppliers: for example, developing the technological competencies of the suppliers, generating suppliers' interest in developing products that the firm wants, carrying out development projects in co-operation with the suppliers, etc. (Wynstra, 1997). Wynstra (1997) further elaborates on the role of age and on the role of the supplier position amongst others. He argues that the older a buyer - supplier relationship, the fewer the contracts, and the supplier's position has no clear correlation with the formalisation of the relationship.

What may be concluded from the above discussion is that the term "role" is used to signify two parameters, namely the impact or the activity/function (Lillecreutz, 1998). When the role is used to describe the effects of length of relationship or the suppliers' tier position, it denotes the impact that these could have on the relationship (buyer-supplier). When the term role is used to denote the role of the purchasing department or the role of the specification or the role of the people involved in product development, then the term role is used in the context of activity/function. This thesis will concentrate on the roles of specifications and contracts in the context of activities/functions that they could perform.

There are certain similarities between product development roles and the roles identified as characteristic of the specifications. It was concluded from the product development roles that specifications could perform both idea generating and gate-keeping roles. As suggested by Kaulio (1996), the knowledge gathering and market investigation roles corroborate with the idea-generating role. Ideas could be obtained from market studies and recorded in the written document called the specification. Analytic synthesis (Kaulio, 1996) also corroborates with the role of idea generating because there could be a synthesis of the ideas in order to narrow them down. Kaulio (1996) suggests that there is a lack of research concerning the role of specifications. Further empirical research is necessary. Further analysis as a result of this thesis may help to throw more light on the roles of specifications and this will be revisited in Chapter (7).

The validation role seems far from clear. Once the final specification is reached, it will serve the purpose of validating the product. In outsourced product development, however, there is a need to validate the specification itself as external parties are involved. Contracts could be helpful in assisting the validation of the specifications (Cooper, 1975; Beecham, 1996) and could also be instrumental in fulfilling different roles. They could perform the role of providing flexibility in outsourcing (Harris et al., 1998). Whenever parties reach an agreement, written contracts fulfil the role of validating that the parties have indeed reached an agreement.

1.6 Introducing the research questions

The present research examines the role of specifications and contracts between OEM firms and suppliers in the context of activities/functions that they may perform. This examination will be done under the assumption that suppliers are involved in the OEM's product development process and are a vital part of the OEM's extended organisation; otherwise there would be no need to study the role of specifications between OEM firms and suppliers. Instead, internal specifications and possible internal contracts within the OEM firm itself could have been studied. The trend towards more outsourcing or involvement of suppliers in the OEM product development process has been ratified by many authors such as Carbone (1994), LaBahn et al. (1994), Lamming (1993), Womack et al. (1990), Clark & Fujimoto (1991), Abo et al. (1994), etc.

This move towards increased supplier involvement requires both internal and external co-ordination between and within the OEM and supplier firms (Söderquist, 1997). This is because organisations, due to external contingencies, become segmented into units, each of which is given a special task of dealing with a specific part of the environment (Lawrence & Lorsch, 1967). This means that the buyer and suppliers engage in specialised tasks and these have to somehow be linked together (Lawrence & Lorsch, 1967). These tasks are interrelated and interdependent and cannot be performed in isolation. This division of labour and the interdependence between the tasks that are carried out by the OEM firm and the suppliers make the need for co-ordination all the more important (Karlson, 1994).

Many scholars fail to recognise the importance of co-ordination which results in problems with realising the product (Karlson, 1994). Simon (1976) sees organisations as "decision making and information processing systems", which, according to Karlson (1994), moves the focus from how people are grouped to the decision process itself. Galbraith (1973) subscribes to the idea of co-ordination being a decision process.[20] The greater the uncertainty,[21] the more information that will need to be processed (Galbraith, 1973). Simon[22] (1976) argues that co-ordination is a process consisting of three steps, namely the development of a plan of behaviour for the members of the group, the communication of that plan to the members, and finally, the acceptance of the plan by all the members. This indicates that the co-ordination of the specific activities and competencies (suppliers focus on parts/components while the OEM focuses on the overall architecture) is essentially a decision process in which transformation of communication and information are important. This focus on communication by both Galbraith (1973), and Simon (1976) could mean that if more emphasis is put on communications (quality, amount, time etc.), the impact on co-ordination would be more positive.

Solutions to the problems of communication include locating specialists groups together, providing them with tools to communicate, etc. (Karlson, 1994). Karlson (1994) suggests that the interdependency between the tasks require co-ordination to be performed on an ongoing basis. Co-ordination could be facilitated by procedures, plans, standardised product structures, the organisational members themselves, etc (Karlson, 1994). According to Galbraith (1973), the organisation can handle task uncertainty in two major ways namely, by reducing the need for information processing (creation of slack resources and create self-contained tasks) and secondly, increasing the capacity to process information (investment in vertical information systems and creation of lateral relations). They are as follows:

[20] "A good deal of information must be processed to co-ordinate the interdependent sub-tasks. As the degree of uncertainty increases, the amount of information processing during task execution increases".

[21] Uncertainty is defined as the difference between the amount of information available and the amount of information required in order to perform a given task (Galbraith, 1973).

[22] The views expressed by Simon (1976) are very formal and mechanistic in nature. Karlson (1994) expanding on the limitations of Simon's model elucidates that co-ordination is of little importance if the development personnel do not understand each other's language. In other words, there is a need for redundancy and the flow of tacit knowledge in the organisation to ensure development performance. Further, co-ordination does not only imply only development, communication and acceptance of the plan, but also includes the joint implementation of the plan by the development personnel (Karlson, 1996).

- **Slack resources** Uncertainty is reduced by increasing the amount of slack, for example, having tolerances, increasing the lead-time to delivery, etc., though this will be at a cost to the customer. The specifications[23] allow the creation of slack as the development personnel could make the different trade-offs with respect to the whole product, described by the specification.
- **Self-contained tasks** Having a number of skills pooled together in a group reduces uncertainty. This reduces the diversity faced by the group and facilitates the collection of all the resources required to solve a problem. The specifications may be worked on by the different groups in charge of the different areas of the final product. The specifications thus facilitate the creation of self-contained tasks.
- **Vertical information systems** The changes in the specifications or targets are used to create a new plan instead of updating the old plan. The frequency of updates would depend on the amount of uncertainty faced. The more frequent the updates, the fewer the number of exceptions referred upwards. The specifications, if updated very frequently, could help the developers to make their decisions on the latest information rather than relying on outdated information.
- **Creation of lateral relations** Lateral relations are created so that the problems are solved at a lower level, thereby decentralising decision-making. Rather than refer problems upward, task forces are formed that could help to solve problems. Specifications facilitate the creation of lateral relations as they form an arena for co-operation and communication for all those involved in the development.

The above discussion illustrates that the use of specifications as support structures (by designers for example) may help in reducing uncertainty, facilitating the decision making process or simply ensure better co-ordination. As stated by Womack & Jones (1994), in addition to co-ordination, the integration of actors within the OEM must be handled. They highlight the need for cross-functional teams where the members are under the authority of a transversal process management function. Clark & Fujimoto (1991) and Karlson (1994) all discuss the importance of integration and co-ordination, but limit it to internal actors and fail to explain the importance of co-ordination and integration between the internal and external actors. Helper (1991) details the

[23] These specifications will have to allow the input of the different personnel and hence, cannot be totally closed.

importance of information exchange and commitment in an OEM supplier relation as "rich information flow both endangers and requires a high degree of commitment to the relationship".

It appears that both co-ordination between the OEM and suppliers and integration in their internal processes is important. Co-ordination requires support structures such as specifications and contracts. Also, co-ordination must be performed on an ongoing basis, as the OEM - supplier tasks are interdependent. Specifications could help in the dialogue process (communication between the participants). Improving communication leads to effective co-ordination between the OEMs and the suppliers on an ongoing basis. Specifications also help in integrating the actors from the OEM and supplier, as they require a joint effort in order to be articulated and turned into a final product. The integrated cross-functional teams at the OEMs may have to include actors from the supplier companies if they (OEMs and the suppliers) have to work together in an integrated manner, for instance, in making joint decisions. By forming a link to the specifications the contracts could assist in their validation. Harris et al. (1998) articulates the usefulness of written contracts in outsourcing by stating that flexible contracts are required to cope with changes in the environment. In other words, since specification writing is done in turbulent environments, (changing customer desires etc.) the need for flexibility (like price, renegotiations, contract duration etc.) is all the more important. Authors such as Cooper (1975) and Beecham (1996) have stressed the importance of contracts in product development, though they do not go into depth as to the contents or the validation aspects of the contracts.

The above discussion indicates that specifications and contracts are important support structures, which help to assist the co-ordination between the buyer and the supplier in outsourced product development. By saying that specifications and contracts are important support structures, I make an assumption that there is an impact on the outsourced product development. Given this impact, it would be useful to know what activity/function these specifications and contracts could perform. As previously stated, when describing the roles of specifications and contracts, the term activity/function is used to signify a role and therefore, I am interested in the roles that could be played by specifications and contracts. For example, it has been shown that specifications could play a role of facilitating communications, thereby improving co-ordination and the buyer-supplier relationship. Thus, it may be hypothesised that one possible role of the specification is to act as a facilitator of communications. This thesis attempts to articulate the different roles that could be played by specifications and contracts. The following research questions[24] are thus pertinent:

Q1: What is the role of specifications in integrated development between the OEM and the suppliers?
Q2: What is the role of written contracts in assisting the validation of specifications in the development process?

1.7 Research Perspectives and Limitations

In order to answer the research question on the roles that could be played by specifications and contracts, exploratory research needs to be carried out to identify as many factors as possible as to the different roles that could be played by the specifications and contracts. The research questions are exploratory in nature and deal with questions of "what" and "how and why" to some extent.

A piece of research must be representative of something (Danielsson, 1983), for example, one must ask questions such as:

- Why is a particular industry being studied?

The industry that was chosen as the field for observation for the research question on specifications was the automotive industry, as it is complex. A complex product warrants the need for co-ordination[25] and since the specifications are being projected as a co-ordination tool, it would be appropriate to study such an industry. It manufactures advanced products and is rich in data that could help identify important factors that are necessary for this research. The auto and aircraft industries (supplementary data) were chosen to provide the field of observation for the research question on contracts. The aircraft industry also manufactures complex products and

[24] These are the main research questions. They will be broken down into detailed research questions as a result of the literature review to be carried out in the next chapter. As a result of answering the detailed research questions I will attempt to answer the main research questions laid down here.
[25] This point was emphasised by Frank McCabe, Vice President, Intel Ireland at the 5th International EUROMA conference in Dublin, Ireland.

engages in outsourcing to the same extent as the automotive industry. The need to validate that the specifications are satisfied is important in both the industries.

- What is the firm's place in the production chain, etc.?

To help answer this question, suppliers with direct and indirect link to the OEM were studied.

The *unit of analysis* was identified to be the specifications taking shape in the interchange between an OEM and multiple suppliers. This includes the establishment of a contract at the start of the relationship and the evolution of the contract during the business relationship in order to validate the specifications. The unit of analysis will be further discussed in the methodology chapter (3). The empirical research was carried out in three phases (Figure 1-2). The first phase was the pilot studies, followed by the case study at the auto OEM (where questionnaires were distributed both internally and externally to suppliers and in-depth case interviews were conducted in five supplier firms), and lastly, supplementary data was collected through in-depth interviews at the aircraft OEM.

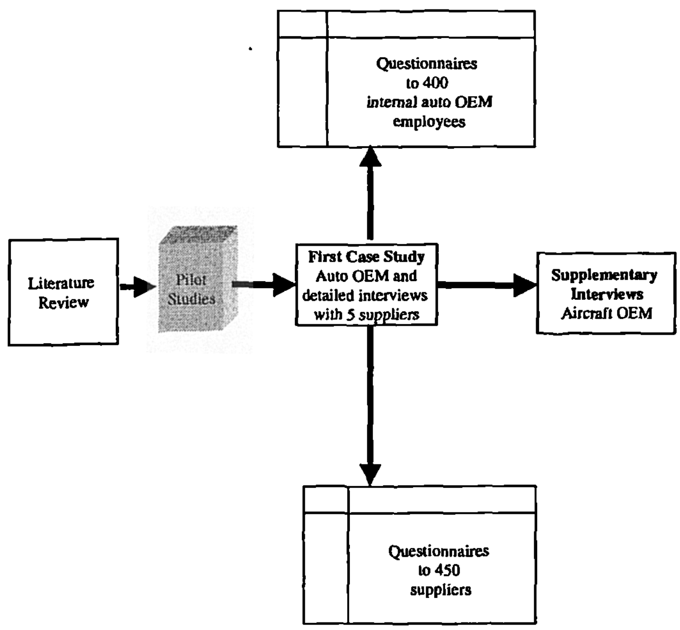

Figure 1-2, The empirical research

The fields of observation, the name of the companies, the products manufactured and the type of study are displayed in Table 1-1

Field of observation	Name of the company	Products manufactured	Type of Study
Auto Industry D+O+S[26]	Auto OEM, Cooling Systems Supplier, Wire harness supplier	Cars, cooling systems, Wire Harnesses	Pilot Studies
Auto Industry O	Auto OEM	Cars	Case Study
Auto Industry D+S	Process Supplier to Auto OEM	Process equipment	In-depth Interviews
Auto Industry D+ S	Wire Harness supplier to Auto OEM	Wire Harnesses	In-depth Interviews
Auto Industry D+S	Cooling System supplier to Auto OEM	Cooling Systems	In-depth Interviews
Auto Industry D+S	Electronics supplier to Auto OEM	Electronics	In-depth Interviews
Auto Industry D+S	Seating supplier to Auto OEM	Seats	In-depth Interviews
Aircraft Industry O	Aircraft OEM	Aircraft	Supplementary Interviews
Auto Industry I+D+S	450 Suppliers to Auto OEM	A range of products	Questionnaires
Auto Industry Internal O	400 employees of Auto OEM	Cars	Questionnaires

Table 1-1, Case companies

This thesis has certain limitations and these will be explained here. As far as contracts are concerned, this study is limited to the validation aspect of contract only. This means a focus on the content of the contracts, as the content is necessary to validate. Specifications that are examined in this study are limited to the process of creation of the document called the "specification" and the written document itself. Parameters outside this sphere such as execution or realisation of the written document will not be dealt with.

[26] S=Supplier, O=OEM, I=Indirect link to Auto OEM, D=Direct link to Auto OEM

1.8 Relevance of the study from a theoretical and practical perspective

The theoretical relevance will be in the ability of this thesis to contribute to the specification and contract literature through modelling and conceptualising. It will elucidate on the understanding of the role of specifications and contracts as a mechanism to improve integrated development between the OEM and the suppliers in outsourced product development. The research will help to improve the current knowledge in the field of specifications and contracts, as there has been limited research on these topics. It is a question of "analytical generalisability" (Yin, 1989), where "the investigator strives to generalise a particular set of results to some broader theory". The objective is not to provide a general answer to the question on the roles of specifications and contracts, but to examine the actual situation in an in-depth case study and compare it to the relevant literature. The managerial relevance will be in the ability of this thesis to provide the practitioners with a deeper understanding of the roles of specifications and contracts, so that they may develop workable tools that can be used in outsourced product development. For example, a deeper understanding of the role(s) that specifications could play in important outsourcing decisions can be helpful in developing tools (process charts, structures, models, etc.) that can aid the outsourcing process.

1.9 Conclusion

The above discussion has focused on modes of integration between the buyer and the supplier in product development and especially in the automotive industry. The modes looked into were specifications and contracts. The brief literature overview indicates movements towards integration between the buyers and suppliers. The integration process could be facilitated by closer co-operation in specification. The nature of the research questions allow the use of the qualitative approach, i.e., an in-depth understanding. The study is exploratory in that the questions approximately guide the interviews and observations. In order to improve the clarity and focus of the study (Miles & Huberman, 1994), a tighter research design has been chosen, where the objective of the literature analysis is to justify the importance of the research and guide the research. The relevance and timeliness of the research is improved by the literature review which is aimed at analysing the important theories and approaches in the field of specifications and contracts, and their impact on the degree of integration of the OEM and the suppliers. The conclusion of the study will result in contributions to existing knowledge, help understand the research issue and also contribute to the understanding of practitioners.

2. OVERVIEW OF PREVIOUS RESEARCH

2.1 Introduction

This chapter gives an overview of the previous research done in the field of specifications and contracts. The purpose of the chapter is to guide the data collection and analysis. This chapter is about exploring what other authors have said about the research questions. There is a need to verify that the theoretical description corresponds to what is needed to answer the research questions and appropriately covers specifications and contracts. The reason for using a theoretical framework to examine the research question is to ensure that the analysis of data can be performed and that new theories, models or reasoning can be created in the areas where existing research is lacking.

Despite the long innovative history of design in the automotive industry and the development of many models and methods, (Hales, 1987) the design process has not been understood and exploited in practice. I will at first survey the previous research done on product development and explore whether parameters like specifications and contracts have been given attention. Since I am exploring the role of specifications and contracts between the buyer and supplier, the need for collaboration will also form an important part of the survey.

2.2 Product Development

Studies in product development can be split into two categories, namely the scientific design view and the practitioner view (Karlson, 1994). The scientific view takes the design process to be rational, orderly, well defined, etc., and therefore possible to co-ordinate and plan in detail. Galbraith (1973) proposes a model where activities are performed in five sequential steps starting with the product design, process design, fabrication, assembly and testing resulting in a completed product. Imai, Nonaka and Takeuchi (1985) observe and describe the product development processes of American companies as sequential. In his study, Coughlan (1992) observed that product development has five distinct phases, namely initiation, definition, development, verification and the first year of routine production. A closer look, however, revealed that the production engineers were involved much earlier and thus the process was simultaneous and not sequential. Clark & Fujimoto (1991) also subscribe to the idea of simultaneous product development, as many of the Japanese companies in their study had overlapping product development stages.

Galbraith (1973) views organisations as information processing networks. According to Galbraith (1973), the greater the uncertainty associated with a given task, the greater the amount of information processed during its execution. Clark & Fujimoto (1991) take a similar view and look at the development process as a total information system. They recognise product development as a process by which data on market and technical opportunities is transformed into information assets for commercial production. These information assets are deployed in the production process. They pass through a number of stages where they are created, scanned, decomposed, transferred to other media like software and are ultimately articulated as product and process design. They focus attention on how information is created, communicated and used, thus throwing light on the critical information linkages within the organisation and also between the market and the organisation.

Clark & Fujimoto (1991) comment that product development creates information assets that represent elements of the future consumption process at a detailed level. It is thus critical to manage the link between the development and the sources of information about future consumption. To guide the importance of consistency in the product development process, Clark & Fujimoto (1991) focus on the way designers, engineers and marketers solve problems at the working level. Key information assets, their creation and their critical linkages must be managed well for effective product development processes. Clark & Fujimoto (1991) refer to an information asset map framework where they identify four major development stages, namely the concept generation, product planning, product engineering and process engineering. Product planning translates the product concept into specification's targets, etc. Product engineering translates the product planning into detailed product designs within the framework of the cost and the investment. Lastly, process engineering translates the product designs into process designs and ultimately into shop floor production processes. Process design information is related to the shop floor arrangements like the material flow, etc., and this information is necessary for determining the actual production factors like tools, workers, etc. There are critical links between the stages and these need to be managed properly. Information in raw form gets transformed into details during the flow in the vertical chain. The vertical links between the stages determine the effectiveness of knowledge transfer across the stages and again they need to be managed effectively and efficiently. Clark & Fujimoto (1991) further comment that neither cost nor component performance is the driving force in many industries, but product integrity is. If there are links between different stages, then there must be an attempt to link the different actors in these stages. It is not only actors, but also the information emulating from these actors that is important. The fusion of this information through a co-operative working environment between these actors is also important. More important are questions such as where is all the emulating information accumulated, where does this information get integrated, etc.

Clark & Fujimoto (1991) have not addressed these issues. They do discuss specifications, but only as the description of products assuming the process of specifying to be tacit. The view expressed in the scientific product design fails to take into account the individual emotions. Individuals working on the specifications are affected by their emotions and this, in turn, will affect the shape of the specifications. Also, the authors conclude that individuals do not affect the specifications even though specifications flow throughout the process and are affected by the way the individuals handle them. This is the same with the other authors. Overall, both the role of specifications (the process of realising the product), and that of contracts as a means of assisting the validation of the specifications have been little researched.

In the "art of the practitioner view", product design is seen in a fundamentally different manner. According to Karlson (1994), the focus is on the synthesis of the whole, rather than on the parts. In the "art of the practitioner view", the importance of reflecting on one's own work is highlighted (Schön, 1983a). That means that the importance of gut feeling, intuition, and feeling for problems at hand takes precedence over the scientific way of organising. Rosell (1990) comments that the only way a designer will construct the whole without knowing the specific parts in advance will be by alternating between them. The whole does not emerge after the specific parts, but rather they emerge in parallel. Bucciarellli (1988) describes the solitary part of the job of design engineers, i.e., where they explore variations in concepts, develop test plans, etc., as "navigation" between object worlds. This means that there are patterns and beliefs grounded in the object being designed. The conceptual side of individual design work is also stressed by Bucciarelli (1988). It is where participants work alone between object worlds i.e. conceptualise, analyse, sketch, etc. In the practitioner view, the specifications will have a reflecting role, whereby the people working on the projects will possess a great deal of tacit knowledge and hence all the specifications will be dependent on the individuals. This also means that the need for co-ordination increases, as the product will not be realised without the designers working together.

Most of the above discussions are internally oriented, i.e., within the company. They fail to take into account the existence of external parties like the suppliers. Though the importance of the design process has been stressed time after time, the role of communication between the designer (from both the buyer and the supplier) in the development process and the validation of the final product (by both the buyer and the supplier) have not been stressed. While the scientific view states that the development process has specifications, the practitioner view emphasises the reflective side of specifications. However, both neglect to explain the role of specifications and contracts in a way that could be used to validate the specifications. Before surveying the relevant literature, the need for collaboration would need to be explored, as it is an important reason to engage in outsourcing product development.

2.3 Collaboration in Product Development

The emphasis in this section is on the need for collaboration in product development in the automotive industry. Collaboration could be affected by the complexity of product development and the extent to which collaboration is possible between the OEM and the suppliers. New product development is large-scale problem - solving (Schrader et al, 1994) for it consists of thousands or even tens of thousands of tasks that must be woven into a complex network of relationships (Von Hippel, 1990). That means that the problem solving process and the tasks are not fulfilled by individuals but need to be partitioned between individuals, firms, etc., (Von Hippel, 1990). Thus, the partitioning of tasks between firms is a challenge, as they need to take advantage of each other's domain of expertise (Schrader et al., 1994).

Competitive parity in the areas of cost and quality has forced today's manufacturers to develop new sources of competitive advantage (Birou & Fawcett, 1993). Collaboration is the preferred route to product development in the information and technology sectors (Bruce et al., 1995) and also when considering ever increasing costs, shorter product lead times, internationalisation of markets, technological convergence etc., (Lamming, 1993, Bruce et al., 1995, Helper, 1991). I will now examine the benefits of collaboration.

There are a number of benefits in collaboration, including the following:

- Spreading the costs and risks of product development, gaining access to technological expertise and exploiting technological synergies (Lamming, 1993).
- Business risks can be shared, supply prices stabilised, etc. The supplier may improve quality, reduce time to market new products /design, etc. (Ellram, 1995).
- Collaboration is the preferred route to product development in the information and technology sectors (Bruce et al., 1995) and also when considering ever increasing costs, shorter product lead times, internationalisation of markets, technological convergence, etc (Lamming, 1993, Bruce et al., 1995, Helper, 1991).
- With technological divergence, one company cannot exploit all the promising opportunities and the more the alliances it can pool, the more likely the chances of a successful outcome (Blonder & Pritzl, 1992).
- It takes a lot of time and money to develop new products and hence collaboration is a must, as companies cannot make it on their own[27].
- To take advantage of the suppliers capability, low costs base at the suppliers, and the superiority of the technology possessed by the supplier (Fine & Whitney, 1996).
- Clark (1989) argues that if the suppliers deliver products that lie on the critical path then there is a good reason for outsourcing as both time and costs can be reduced
- Quinn & Himer (1994) comment that strategic outsourcing can give a company "the full utilisation of external suppliers investments, the innovations and specialised professional capabilities that would be prohibitively expensive or even impossible to duplicate internally".

[27] One can look at the recent merger (1998) between Daimler Benz and Chrysler to observe this trend.

Though there are several benefits of collaboration, not all collaborations are successful, as there are certain negative aspects to these collaborations. They can be listed as follows:

- Harrigan (1986) suggests that collaborations can be costly and unsuccessful and that the expectations of the collaborating parties are not always met.
- There might be costs associated with the time and effort needed to manage these collaborations.
- Care must be taken to harmonise the different cultures of the collaborators and regular reviews must be done to monitor the progress of the collaboration.
- Porter (1990) suggests that most alliances are unstable as alliances are directly related to the trust between the collaborating parties. Trust is something that is subjective and cannot be measured and hence the logic of instability. For collaboration to be successful, there needs to be a certain degree of trust.
- Gugler (1992) suggests that key competencies, which are the source of the company's competitive advantage, should not be disclosed. However, this is not possible given the range of communication taking place at various levels within the companies.
- Managerial commitment from both parties is a necessary condition for any collaboration to work (Bruce et al, 1995).

In spite of all the disadvantages, there are many authors who comment on the need for early involvement of suppliers. Early involvement is really a positive effect of the lean supplier (Lamming, 1993). Asmus & Griffin (1993) comment that many organisations such as Honda, Ford, etc., are rethinking and developing their internal functions in order to enable efficient ways of dealing with the suppliers. Such rethinking including and not limited to supplier development as opposed to supplier quality assurance, joint evaluation of the relationship, resident engineers to solve problems (Lamming, 1993), joint information systems to solve problems in real time (Soderquist & Nellore, 2000) have helped many companies to slash development times by as much as forty percent. Leading companies select suppliers before they commence design of products so that the suppliers become a part of the product development team. According to Birou & Fawcett (1993), the purchasing department should promote early supplier involvement, especially in design and concept, seek greater supplier investment in R&D, facilitate supplier risk taking and creativity etc.

Given the risks associated with the buy decision, the make/buy decision has to be made as carefully as possible. This means that not only have the advantages of collaboration need to be looked into but also the disadvantages of collaboration need to be looked into when making the make/buy decision. Many of the advantages for collaboration translate into a buy decision. However, it must be remembered that there could be range of collaborations with different levels of expectations. In other words, the buy decision can be made under a wide range of collaboration levels. In order to articulate the make/buy decision, several authors[28] like Quinn & Hilmer (1994), and Venkatesan (1992) have developed models that allow the make/buy decision to be based on multiple criteria, thereby compensating for the disadvantages of collaboration. I will discuss these models one after the other.

2.3.1 Outsourcing Models of Quinn & Hilmer

Quinn and Hilmer (1994) link many of the parameters that form both advantages and disadvantages in collaborations, and develop two dimensions for classifying the many different activities [development / production of components or products, service or support activities] that a firm deals with, namely *the potential for competitive edge* and *the degree of strategic vulnerability.* The different activities, that require different types of relationships with the suppliers, are classified into three groups (Figure 2-1).

[28] Please look into the attached paper in Omega for a deeper discussion on outsourcing models

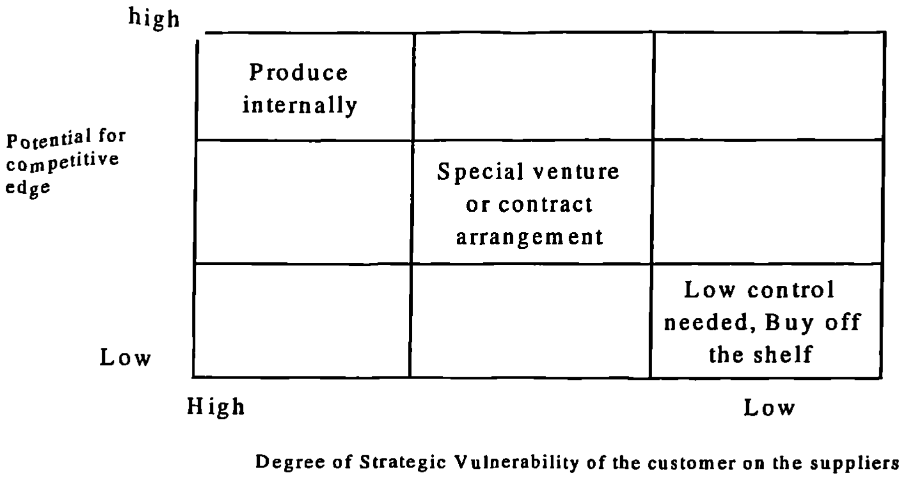

Figure 2-1, Strategic Outsourcing from Quinn & Hilmer (1994)

Quinn & Hilmer talk about activities in general without making an explicit difference between parts and intangibles. This corresponds to the perspective chosen in the paper, as explained in the introduction. The model of Quinn & Hilmer suggests that activities with a high potential for competitive edge and a high degree of strategic vulnerability should be realised in house. Moderate strategic vulnerability and moderate potential for competitive edge represent activities that call for a range of relationships like short-term contracts, call options, long term contracts, retainer, joint development, partial ownership or full ownership in relation to the suppliers. Lastly, activities with low vulnerability and low potential for competitive edge call for arm's-length relationships with the suppliers.

2.3.2 Outsourcing Model of Venkatesan

This model indicates that there are two types of products, namely core (that are strictly produced in-house, because they are critical for the performance of the end product and the OEM is distinctively good at making them) and non-core (that are produced with the help of the suppliers, because they are less critical and the OEM lacks the expertise for producing them efficiently). The core products of Venkatesan (1992) correspond to the in-house products of Quinn & Hilmer as both the core and in-house products are produced internally without any supplier involvement.

However, Venkatesan (1992) does not specify the type of relationships that could be used when engaging suppliers for the non-core products.

2.4 Specifications-An overview

Japan's main source of competitive advantage has been its ability to bring new high quality products rapidly to market in the global automotive industry (Ward et al, 1995). Industry experts with whom initial interviews were conducted revealed that specifications could have been a factor contributing to the success of the Japanese. Before I go any further into the literature review[29], the detailed research questions[30], which will emerge after the literature review, will be laid out in order to help the reader.

1.	*What are the different elements that can be contained in a specification?*
2.	*What are the impacts of the network of suppliers on the role of specifications?*
3.	*What are the issues faced by OEMs with regard to the role of specifications?*
4.	*How can visions for suppliers be created and deployed leading to a positive impact on outsourced product development?*
5.	*What are the possible impacts that visions for suppliers may have on the core capabilities of an organisation?*
6.	*How could the role of specifications be illustrated with the help of a conceptual model?*

As sections of the literature are examined, the pattern leading up to the detailed research questions will be apparent. This will allow the readers to use the research questions while reading the literature review. It will also allow the author to mark the patterns leading to the detailed research questions, as the different sections in the literature review are being covered.

Two researchers in operations management (namely Everett, E. Adam. Jr., and Paul, M. Swamidass)[31] have attempted to assess operations management from a strategic

[29] When the author conducted a search for literature on the topic of specifications there were a number of references that were obtained. In order to rank the references in some order of importance, a literature search was conducted to find out as to how the references could be assessed and thus, emerging questions reflected on. The literature search obtained an article on the organisation of operations management literature, which was then used as a basis for the organisation of the section on specification literature.

[30] Detailed research questions arise after a full literature search.

[31] Adam, Jr. E.E. & Swamidass, P.M., (1989), Assessing operations management from a strategic perspective, *Journal of Management*, Vol.15, No.2, 181-203

perspective by using a specific method[32]. In order to do so, they reviewed the literature under the theme of "The core content of manufacturing strategy includes cost, quality, flexibility and technology". The authors first chose a representative sample of the current body of manufacturing strategy literature and identified the content variables in each of the writings. The authors conclude that although they have carefully examined the studies, the interpretation of the authors intended content variable could be a potential source of error. Using concentric boxes, the most frequently mentioned variables are placed at the core and less frequently mentioned variables far away from the core. In this way, the most common themes can be identified. The less researched variables can also be identified.

The above discussion shows a structure when writing a literature review. In the research question on specifications the above structured approach will be followed. The main points in the structured approach are as follows:

- List the most representative sample of authors in the specification literature
- Identify the message that these authors intend to convey
- There is bound to be error/inconsistency in the interpretation of the content variables
- Identify the content variable most frequently mentioned
- Draw concentric boxes to identify the most popular content variable and map it to the least popular concentric variable. This will also help identify the less researched and most researched variables.
- Comment on each of the content variables and their applicability to the research question. Identify possible drawbacks in the current literature so that the research questions can have a firm base in current literature.

The literature analysis on specifications begins with the list of authors and the content variables as shown in Appendix 7. After this, the concentric boxes are drawn to identify the most popular topic as opposed to the least popular topic. This is represented in Figure 2-2. The most important content variables[33] are listed in Stage

[32] This method is bibliometric as it allows the reader to pose questions and reflect on the conclusions reached by each of the authors. The conclusions reached by each of the authors are not the absolute truth.

[33] The topics have been ranked in order of importance only in terms of frequency of coverage by authors.

0, followed by Stage1, Stage 2 and Stage 3. The literature review will be structured in the same way. First I will discuss Stage 0 and then continue sequentially until Stage 3.

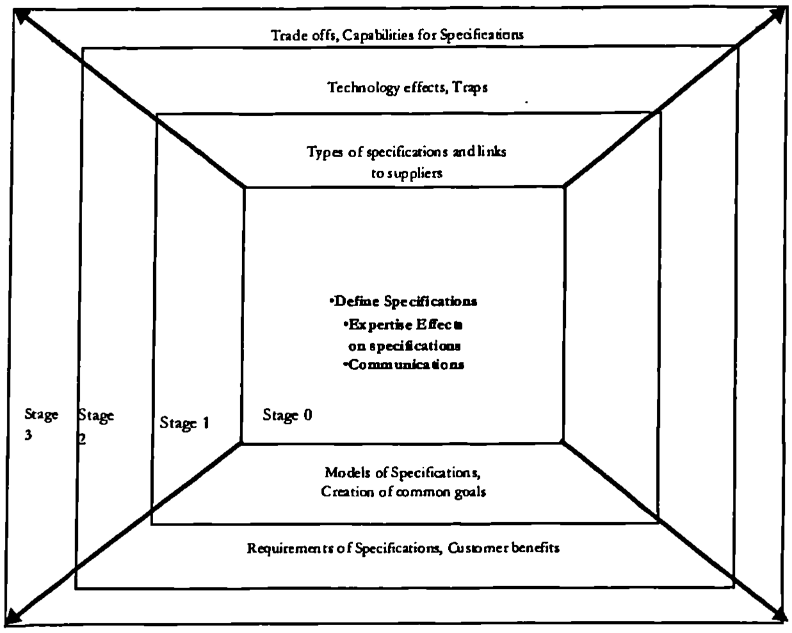

Figure 2-2, Content variables making the core and outer boxes

2.4.1 Core elements: Stage 0

The core elements are those topics that have received the most attention in specification research in the automotive industry. The topics include the meaning of a specification, the expertise effects on specifications, and finally, the communication of specifications. Many definitions of the term specification cause confusion and these different definitions will be discussed here. Different definitions of the term specification could lead to a misunderstanding of the role of the specification by both the buyer and the supplier. The modes in which the specifications are communicated will also be explored. Certain roles of the specification may require certain modes of communication. Finally, since specifications may be affected by the expertise present in an organisation, the expertise – specification link will be explored. The expertise present in an organisation could actually shape the way in which the desired role of the specification is executed.

2.4.1.1 Define specifications

Specifications have been defined in a number of different ways. Smith & Reinartsen (1991) define them as the written description of products that are generated in advance to guide the development of the product. Hollins & Pugh (1990) define the specifications as the systematic activity necessary from the identification of a market or user need to the selling of a product to satisfy that need. Elliot (1993), commenting on the process of defining the requirements in the early part of the design process, said the following: "..to turn the abstract and (usually) ill-formed idea of the customer (his dream) into a concrete statement of requirements against which the supplier can tender and carry out detailed design (a specification)". In Iansiti's (1995) interviews, an engineer described a specification as one that provided certain envelopes to stay within. Some of the parameters in the specification were fixed such as the size of the box, power outlets, etc., while the rest of the parameters could change.

The process of arriving at a specification has been well documented by Smith & Rhodes (1992). Each stage in the process of specifying leads to a straightforward compilation of information. Information on details is added and the content of the specification is progressively increased. A recent study by Söderquist (1997) indicated that specifications could contain data on the following:

- The scheduled order quantity for the finished product
- Design study lead time
- Quality demands
- Unit price for ordered quantity
- A written functional description
- Competitive situation
- Internally generated budget and cost price etc.

What was not mentioned, however, was whether the final specification or the transitional stages of the specification contained these data. This confirms Kaulios' (1996) contention that many researchers have not understood the complexity of the specifications, their roles and transitional phases.

Smith & Rhodes (1992) illustrate the formation of the specification in a stage by stage approach including steps such as determine objectives, search and locate, obtain, sort and collate, synthesis and analyse and finally apply. As the stages are completed, the assimilation of information increases and so does the knowledge and understanding. Smith & Rhodes (1992) comment that the market needs have to encapsulate the search in the following areas in order to satisfy the objectives:

- Business & Statistical
- Competitive and analogous products
- Patents
- Standards, codes, regulations and legislation
- Books, papers and reports
- Manufacturing facilities
- Specialists
- Buyers and users

This information is fed into the specification thereby increasing its content. The information from these areas many be enormous and Smith & Rhodes (1992) point out 32 primary elements such as:

- Aesthetics
- Company constraints
- Competitors
- Customer
- Cost of the product, etc.

From the above discussion it is apparent that there are many parameters that can go into a specification. Söderquist (1997) mentions some of these parameters and Smith & Rhodes (1992) mention others. It is evident that the authors have concentrated on the elements that can be considered in a specification. There could be many elements in a specification. Hence, all attempts to create a list of specification elements can be met with resistance by academics, i.e., "so what" as there could be other elements. It appears from the above discussion that, instead of concentrating on the elements, it is more vital to understand the factors that could be given to the suppliers based on their capabilities in order to promote mutual understanding between the buyer and the supplier. If there is so much information, then there is a need to analyse it, discard the irrelevant details, and thus concentrate on the important information (Smith & Rhodes, 1992). There is a diverging phase (Kaulio, 1996), where information is collected, and a converging phase, where there is consolidation or convergence of information. The information has to be sorted and collated in order to synthesise and analyse, thereby undergoing a converging phase. There could be diverging phases after the converging phase has commenced, as there may be particulars that need additional data. As the project grows, there is a need for more data in the converging diverging phases so that the specifications can be updated and turned into a workable document. The specifications change over time and this point has been re-emphasised.

There are a number of different definitions of specification, which could lead to confusion. This may be minimised by creating a common understanding of the specification parameters between the buyer and the supplier. The confusion could arise because the buyer and the supplier can interpret the same messages in different ways. It can be concluded from this section that there is a need to generate a common understanding of the elements that constitute a specification so that its role can be understood in the same manner between the buyer and the supplier.

2.4.1.2 Expertise effects on specifications

Kaulio (1996) observes that specifications change over time in relation to the user and are not static. Kaulio (1996) further points out that specifications are an arena for co-operation amongst the different actors in the design process. Therefore, it is important to examine the effects of the expertise on the specifications. If the partners (the OEM and the supplier) do not reveal knowledge related to their domain of expertise, there could be a misfit (unclarity), or if the partners state requirements not in their area of expertise, there could be (restrictiveness) (Schrader et al, 1994). According to Schein (1985), restrictiveness occurs when there is limited trust in the suppliers. Clark (1989) comments that the long tradition of OEMs doing everything in-house makes it all the more difficult to involve the suppliers and thus the OEM specifies to a very large extent.

According to Scharder et al. (1994) it is hard for the engineers to accept that the suppliers are experts due to the fact that the specifications are their requirements and thus, they tend to break it into great detail. If the problems occur in the engineer's sphere of responsibility (Schrader et al., 1994), then there could be negative personal consequences and as a result the engineers tend to do everything. There are other reasons for unclarity (Schrader et al, 1994), such as unclear tasks, changing situations, high cost of clarity and lastly, the engineers may wish to refrain from stating certain requirements that might be in conflict when individuals have different goals. The effects of unclarity could be that the solutions are of a poor quality or there may be changes in the product development process etc. On the other hand, the effects of restrictiveness could be many such as:

- the lack of motivation to seek better solutions
- generation of early specifications based on preliminary problem analysis
- no search for other solutions, and finally
- delays as the customer specifies out of his domain of expertise (Schrader et al., 1994).

On many occasions, the design staff refused to generate the specifications, saying that it was the responsibility of the marketing staff (Karlsson & Åhlström, 1996). Perhaps they were trying to push the blame onto the marketing staff, in case there were problems. The design staff were not using the specification as a working document. This also means that there could have been problems as the whole product[34] is realised by iterating between the whole and "parts of the whole" according to the practitioner tradition. The wholes and "parts of the whole" are constructed by having clear specifications and by iterating between them. Though they can be agreed upon that at the beginning of the process, the specifications are hard to visualise, every attempt must be made to write the ideas down and then iterate them between the

[34] Whole product refers to the complete product like the auto. "Parts of the whole" refer to the parts that constitute the whole product like the engines or wheels for an automobile.

actors. This allows the specification to be used as a working document while also allowing the actors to co-operate.

Karlsson & Åhlström (1996) also observed that there were requests for detailed specifications in their case study company. Liker et al. (1995) comment that if the increased information complexity as a result of increased supplier collaboration is to be managed, then the OEMs will have to carefully think over the specifications that they give to the suppliers. Hence, the overall specification has to be decomposed in such a way that the decomposed parts are integrated and add up to the overall specification (Liker et al., 1995). Integration of the different parts of the specification is necessary in order to have one document called the specification. This also means that the different constituents of the specifications will have to be integrated. This calls for collaboration and commitment on the part of the people working with the specifications. The observations from the above discussion are that both the role of specifications and the role of written contracts as a driver of specifications have potential for further research.

The specifications may have to be written for the whole product or can be written for parts of the product, as the existing specifications may suffice for the remaining parts. The specifications can be restricted due to certain legal demands and hence have to take many factors as given before the start of the specification writing process. Karlsson et al. (1998) comment that the specifications can be affected by the cost. The converse is also true as the costs can affect the specifications. In other words, the quality of the specifications has a direct bearing on the costs that have been targeted for the part in question. Clarks (1989) explains some of the above mentioned points with the help of the critical path analysis. The extent, to which parts are developed in-house, as opposed to outsourcing the parts, is called "scope" (Clark, 1989). This refers to the extent of involvement of the buyer in the specifications. The scope depends on the critical path and unless outsourcing can reduce lead-time[35] in the critical path it would make better sense to in-source the parts.

The suppliers therefore have to bring in additional capability to the project so that the lead-time is reduced. The extent to which the specification formation can involve

[35] Lead-time is only one of the factors identified by Clark (1989).

suppliers depends on the ability of the suppliers to reduce the lead-time in the critical path. The critical path is the factor determining who generates the specification, the extent of carryovers in specifications, etc. The concept of carryovers from one project to another can be extended from one platform[36] to another. Between platforms, specifications are generally different, whereas within platforms, they are modified to a limited extent. Typical examples within a platform would be changes in the display dials, a small variation in the headrest of the seat, an extra cup holder, etc., whereas changes between platforms are in the overall architecture of a vehicle such as the chassis, wheel base, etc. The specification thereby depends on the type of project. The changes in the specification are directly proportional to the type of project. In other words, the more radically new the project, the greater the changes in the specification. In relating to the work of Smith & Rhodes (1992), it is quite apparent that the more radical the project the more time spent collecting information about the project and consequently in the converging and diverging phases of collecting information.

2.4.1.3 Specification and Communications

Good communication both between the buyer and supplier, within the OEM and also within the supplier firm, is necessary for specifications. A review of communication patterns is necessary to clarify this. Wheelwright & Clark's (1993) model of communication fits well here as it presents different modes of communication such as those of early involvement, etc. According to Wheelwright & Clark (1993), there are four modes of communication between the upstream and downstream, i.e., between the supplier and the buyer. There are also four dimensions of communication, namely the richness of media, the frequency of communication, the direction of communication and the timing of communication. The dimensions are on a scale from poor to good. The richness of media could be from sparse exchange of documents to a very interactive face to face exchange of information. The frequency could stretch from low and/or infrequent to a very high, frequent and interactive communication. The direction of communication can vary from one-way

[36] A platform is representative of a particular category of cars that have common characteristics. A platform consists of a collection of assets that are shared by a set of products. They are components, processes, knowledge, people and relationships. Robertson, D & Ulrich, K., 1998 Summer, Sloan Management review, 19-32

communication to a two-way dialogue between the parties. The timing of communication can stretch from late communication, such as after the design work has been completed, to a very early communication and, thus, early discussion of problems.

The first mode of communication (Wheelwright & Clark, 1993), is the serial or batch mode of interaction where the buyer does all the design work and transmits all the completed information to the supplier at one time. In effect, the buyer does not take into account the input from the seller and thereby might not benefit from the strengths of the supplier. Hence, as per the communication dimensions, the timing is late, the direction is one way, the frequency is low and the communication is sparse.

The second mode of communication is the early start in the dark where the suppliers start work on their own without any information from the buyer (Wheelwright & Clark, 1993). The buyer informs the supplier in a one shot transmission about the completed design. Though the buyer and supplier work in parallel, they do not share information and thus they may be working on totally different ideas, leading to a period of confusion when the one shot information is communicated to the supplier. This confusion can increase the actual lead-time of the process, though if the areas worked on by both the parties are complementary, the lead time can actually be reduced. This kind of communication occurs when the supplier feels that in order to survive, he needs to get going early in the process.

In the third type, namely early involvement, the buyer engages in active communication with the supplier, however, only after a substantial part of the design is done (Wheelwright & Clark, 1993). There is sharing of information and joint problem solving even before the design is completed and finalised by the buyer. The suppliers start their design work only after the buyers have finalised theirs. This joint solving tends to reduce delays, as there is a better understanding of the issues.

In the last type, namely the integrated problem solving mode, both the buyer and the supplier engage in discussions right from the beginning (Wheelwright & Clark, 1993). The thoughts and ideas are shared from the start. In effect, there is integrated problem solving.

Alexander (1985), signifying the importance of good communications, said the following: "*Innovative design does not sell itself but that it depends on the creative communications skills and positive commitment of marketing staff working in conjunction with the designers to ensure the commercial success of a product.*" This means that both commitment and creative communication skills are necessary for a good design process. The importance of communication is further emphasised by Clark & Fujimoto (1991), who suggest that there is an acute need to tear down barriers between different functions within an organisation such as purchasing, engineering, etc. Integration of functions in an organisation will lead to increased co-operation between the different actors. However, increased co-operation alone is not enough. Rich two-way communication is also a necessity for effective integrated problem solving cycles (Clark & Fujimoto, 1991). Differences in skills, knowledge, education, experience and background can all contribute to mis-understandings, so in effect, better communication would not help.

In order to be able to understand the other actors in the development process and put forward the right questions etc., there is a need to understand tacit knowledge possessed by the other actors (Karlson, 1994). Hence, interpretation of information and understanding of tacit knowledge are important factors in the product development integrative process as tacit knowledge is a reflection of the skill possessed by an individual (Söderquist, 1997). Since, there are thousands of interfaces, components, etc., in an automobile, it is difficult for any one person to keep track of all the components at any given point in time. Many of the tasks have interfaces and interdependence may exist between different tasks. The interdependence between these tasks leads to co-ordination which is further defined by Mintzberg (in Karlson, 1994) as an activity that needs to be performed by any organisation if it is to run. Communication and co-operation can be hampered if the actors have different professional affiliations (Karlson, 1994).

Karlson (1994) suggests that the complexity of tasks puts increased demands on co-ordination, which cannot be performed by generalists but by people with narrow or specialised skills. Integration of these specialists thus becomes a critical issue of concern. New product development consists of a complicated process with numerous inputs, which need to be co-ordinated and integrated, thus signifying the need to improve communications.

The above discussion indicates that the specifications are dependent on good communication. There are different communication modes as well as different categories of suppliers. One obvious question concerns what communication mode in the specification may be utilised with a particular type of supplier. Furthermore, if communication is a vital element in specification, then shouldn't the communication - supplier interface be mentioned as one parameter within the specification itself, so as to better articulate its role? Also the form of communication has not been studied, i.e., whether a detailed specification or a drawing alone will be transmitted in these modes? Though it has been mentioned that one person alone cannot have all the knowledge and that development tasks are inter-dependent, little has been said about how to achieve co-ordination. The specifications can be seen as performing the role of co-ordination by bring actors from different professional affiliations together in order to improve communication and quality of the product.

2.4.2 Stage 1 elements

The topics that will be discussed here are in decreasing order of importance (in this research) as compared to the core elements. In this section, I will discuss the different types of specifications as different specifications could have implications for the suppliers. In other words, I will examine the link between the categories of suppliers and the type of specification that they receive. This could also mean that a particular role of the specification could be to allocate the "right" specification to the supplier based on his capabilities and capacities. The different types of suppliers will be explored, as the different kinds of specifications may necessitate different categories of suppliers. The different models of specifications will also be explored, as these models describe both the specification process and the way in which the written document called the specification is obtained. Finally, the creation of common goals between the buyer and the supplier to aid specification work will then be examined.

2.4.2.1 Types of Specifications and links to suppliers

While there has been no detailed study on specifications, Haslam (1988) has identified five different types of specifications, even though it is not necessary for the complete specification to fit into one of these types. This theoretical development can shed light on the different possibilities or types of specifications. The specifications can be closed, open, restricted, exclusive and negative. In the closed description, there is no need for any supplier input as the specification is complete in all respects. The closed specification offers a complete description of the item. In the open specification, the standards /functionality to be met are given to the supplier and the supplier is asked to supply appropriate samples. In the restrictive specification, the supplier is asked to restrict himself to the use of certain items or sources, etc. In the exclusive specification, the use of certain goods or materials is prohibited. In the negative specification, items are written in a negative way, for example, instead of stating that an item should withstand a 13-kg. weight, it would state that the item should withstand a force of not less than 13-kg. The point is why to apply a higher weight when not needed. While the different types of specifications can be used individually, a complex item like an automobile would require an integrated specification, i.e., a mixture of some of the above-defined categories. This is because the automaker may employ different modes of collaboration such as total outsourcing, joint development, etc., with the supplier and this would thus necessitate the integrated specification.

Smith & Reinartsen (1991) discuss other types of specifications like the weak specification. A specification could be weak (inconsistent, poorly structured, unachievable etc.) if the marketing department works in isolation. In isolation they might generate inconsistent goals. If the engineers do not debate on these goals, the likely result will be a weak specification. For example, Smith & Reinartsen (1991) state that the isolated work of marketing and the no-debate policy of the engineers can lead to a product that is designed superbly, and yet, have a cost that is twice the target value. This shows that conflicting goals need to be discussed from the beginning. Poor specifications can occur due to the following, according to Hollins & Hurst (1995): Omissions, misleading requirements, unclear accuracies, inconsistencies and impossible requirements.

The different types of specifications may confuse the OEM when it makes the important decision concerning the specification supplier match. The explanation of the different types of specifications does not specify the type of specification to be given to the different categories of suppliers. If this is not done and there is no match between the supplier and the specification, there could be problems, as the supplier will not be able to understand the specifications.

Based on their capabilities and capacities, the suppliers can interpret specifications in different ways. Hence, it may be beneficial for the capabilities of the suppliers to be noted from the beginning of the project/s and specifications tailored accordingly. There are different authors who classify suppliers in a number of different ways. Kamath & Liker (1994) comment that not all-first tier suppliers are considered or treated equally. They classify the suppliers as partners, mature, child and contractual suppliers. Contractual suppliers are also known as commodity suppliers.

- Partners are at the top of the hierarchy; they develop entire sub-systems and are collaborative members during the setting of specifications.
- Mature suppliers have very small differences from the partners as they too design complex assembly but are given the critical specifications.
- Child supplier designs simple assemblies to the detailed specification of the assembler.
- Contractual suppliers are those who develop and manufacture standard products which can be ordered from a catalogue.

In order to acknowledge that suppliers have different capabilities and capacities (Araujo et al, 1999) propose that companies need to have different types of interfaces with their suppliers. The type of interface used in a relationship will have direct consequences for the way the resources of the supplier are activated (Araujo et al, 1999). This argument can also be extended to the type and quality of the interface used between engineering and purchasing within a firm. Araujo et al (1999) propose four interfaces namely, the standardised, the specified, the translation and the interactive.

- The standardised interface corresponds to contractual suppliers.
- The specified interface corresponds to child suppliers.
- The translation interface corresponds to mature suppliers.
- The interactive interface corresponds to partner suppliers.

Though Araujo et al (1999) don't acknowledge the contributions of Kamath & Liker (1994), the characteristics of the interfaces described are exactly the same. For example, Araujo (1999) elucidates that in a specified interface, the suppliers' are given precise directions by the OEM. Kamath & Liker (1994) have not named the interface but elucidated that child suppliers require detailed specifications from the OEM. A further example would be the translation interface where directions are given to the supplier based on the context and functionality required. This, according to Kamath & Liker (1994), is a mature supplier who requires rough specifications from the OEM to commence work.

Ward et al (1995) defines the suppliers' design relationship with Toyota on three levels, namely partnership, parental and mature. Toyota, according to Ward et al (1995), varies the supplier design responsibility according to the capabilities of the supplier.

- The first level of partnership (for example, with suppliers of alternators) is characterised by the situation where the suppliers do a lot of work before the OEM and present a lot of concepts/alternatives to the OEM. This is similar to the partner suppliers proposed by Kamath & Liker (1994).
- Mature suppliers wait for the OEM to define their needs and then begin development.
- Parental suppliers have very little input and design to OEM specification. This corresponds to Child suppliers as proposed by Kamath & Liker's (1994).

Cusumano & Takeishi (1991) categorise the role of suppliers into three different modes with respect to product development.

- The first are those suppliers that develop parts on their own without any input from the OEM firms; these are referred to as supplier proprietary parts. These correspond to the Partner suppliers' as described by Kamath & Liker (1994).
- The second are those suppliers who do detailed engineering based on the functional specifications provided by the OEM firms or, in other words, black box parts. This corresponds to the Mature suppliers' as described by Kamath & Liker (1994).
- In the last category are the suppliers who produce according to the detailed specifications provided by the OEMs. These correspond to the Child suppliers' in the Kamath & Liker (1994) typology. The discussion about Contractual suppliers' is not undertaken by Cusumano & Takeishi (1991) and Ward et al (1995).

The above discussed categorisation of suppliers' essentially points towards the existence of four types of suppliers' namely, the Partner, Mature, Child and Contractual. If there are different suppliers with varying capacities and capabilities, then it may be necessary to create a match between the specifications given to them and their capacities and capabilities. This fact may be considered when communicating the specifications to the suppliers so that, problems can be overcome in the specifications. The link could also be considered in the supplier network, as this network could contain suppliers of more than one category. As the supplier network is penetrated, the degree of knowledge[37] that can be contributed to the OEM by the suppliers also reduces. Hence, the role of specifications that are awarded to the suppliers deep inside the network should be to provide as complete information as possible. Specification writers may thus have to explore the different types of specifications while at the same time continuously evaluating the specification-supplier match[38]. This discussion pertains to effect of the network[39] of suppliers on the role of specifications.

[37] The suppliers deep inside the network are those with whom the OEM has no direct contact. In line with the research conducted by Lamming (1993), the suppliers deep inside the network have no direct links with the OEM and thereby, have no technological influence on the OEM.
[38] Competition will exist only within a category and not between categories of suppliers. This is because the categories of suppliers' cannot deal with all types of specifications and have certain limitations as explained by Kamath & Liker (1996).
[39] This denotes the link between the suppliers that have direct contact to the OEM (first tier suppliers) to all the sub, sub-sub suppliers, etc., of the first tier supplier.

2.4.2.2 Models of specifications

Smith & Rhodes (1992) comment that the need for understanding and interpreting market needs and encapsulating them in the product design specification (PDS) is all the more important with intensified global competition. Smith & Rhodes (1992) investigate and develop an information-processing model that would be useful in generating a good and thorough specification. The steps of the model are as follows:

- Determine objectives such as in the extent of search (locations) and the benefits expected (areas to be identified in the competitive products)
- Search and locate the manufacturers and distributors of the competitive products
- Obtain the information
- Sort and collate the information
- Synthesise and analyse with the help of tools and deduce
- Apply as in extraction of data from information areas relevant to each PDS element and decide on the information to be incorporated in each PDS element

Roozenburg & Dorst (1991) also propose a framework of activities that need to be performed during the specification process. The first is to collect the goals and objectives, the second step is to analyse the objectives, and the last step is to formulate the requirements.

Most of the above models do not take the supplier into consideration. In other words, how would the specification change if there is outsourcing? Would the steps in the models change? Also, the models lack an explanation of how to deal with the different types of specifications. Would the steps change for the different types of specifications or would they remain the same? The above models can be seen as belonging to the scientific tradition, as they do not take into account the reflection side of specification work and also fail to comment on the divergence and convergence of information. Lastly, these models have shortcomings, some of which have been discussed above.

Traditional arm's-length models of product development have been derived mostly by observations in the mature industries such as the automotive or appliance industry

(Iansiti, 1995). This has also been pointed out by Mudambi & Helper (1998) who observe a model of close, but adversarial buyer supplier relationships in the US auto industry. In other words, there is formal co-operation with non co-operative behaviour with short-term profit maximisation being the goal of the buyer. These models emphasise a sequential approach and avoid unnecessary changes. In other words, they have a well-defined product concept and specifications. On the other hand, in uncertain environments the processes cannot be so rigid. Outsourcing could be seen as adding to uncertainty as there are independent suppliers involved. This means that in outsourced product development the conditions change. Iansiti (1995) gives the example of a company that embraces change. This represents a development that is characterised by flexibility and responsiveness. In the traditional model, the concept freeze is much earlier in the development process, whereas in the flexible model it is much later and nearer to the market introduction. Iansiti (1995) suggests that the flexible product development process can be a source of competitive advantage in environments where technological evolution and competitive requirements are largely unpredictable. For example, in software and telecommunications sectors.

A complementary perspective can be obtained from the research done by Ward et al. (1995) on Toyota's specification process. Toyota is a "world class company" and can help to identify important factors that have contributed to them being given this appellation. Ward et al. (1995) comment that Toyota delays decisions and provides hard specifications very late in the process in order to ensure that the wrong decisions are not taken. It is for the same reason that they work with an excessive number of inexpensive prototypes including digital/virtual prototypes. Toyota begins designing and building body-stamping dies before all the drawings are finished. Toyota provides ranges in the specifications and then narrows it down rationally. In other words, Toyota uses a set based concurrent engineering approach. The difference between a set based and a traditional concurrent approach, (Liker et al, 1996), is that in a set based approach, a set of possibilities are narrowed down rationally, whereas in the case of a traditional concurrent approach (point based approach), there is only one possibility that is tested (both the traditional and set based approach are executed with cross functional teams) but the approach is still point based. However, even the set based approach has problems. According to Liker et al. (1996), in many cases the suppliers found the ambiguous targets frustrating and preferred more straightforward targets and only some suppliers could handle this ambiguity. Toyota communicates a whole set of possibilities simultaneously and avoids changes that move out of the set (Ward et al, 1995). As a result they reduce the frequency of communications, eliminate the need for co-location, etc. The above discussion gives a good theoretical background. Toyota's approach, which will be referred to in the analysis and conclusion chapter can be summarised as follows.

- **Define a set of solutions at a system level**
- **Define a set of possible solutions for the various sub-systems**
- **Explore sub-system solutions in parallel**
- **Narrow down and converge to a single solution**
- **Do not change until absolutely necessary**

All the suppliers present Toyota with their latest developments and present one to three concepts with suggestions about the most promising ones (Ward et al, 1995). The presentations include comparisons to other designs, test data, and working prototypes. Toyota, on the other hand, gave the suppliers extensive suggestions on improvements. In every case, the presentations preceded any information or statements from Toyota about the new model, but the suppliers were able to proceed because of their long relationship with Toyota and their understanding of the market trends. In contrast, the US manufacturers develop a list of specifications in-house, ask the suppliers for proposals and then choose the lowest bidder, according to Ward et al. (1995). Before embarking on a project, Toyota gathers information from the suppliers, understands the possibilities of the products etc. If the suppliers exceed their target, then it becomes the new specification, otherwise the supplier can show Toyota that the specification is not possible to attain and a new level (lower than the target level) of specification can be reached.

Sobek II et al (1999) have recently identified principles that are at the core of set based concurrent engineering practices. These principles are three-fold, namely, mapping the design space, integrating by intersection and establishing feasibility before commitment and are as follows:

Map the design space

- Explore a set of design possibilities within the problem area.
- Each functional department explores the constraints on its systems and sub systems, i.e., they explore what can and cannot be done.
- Explore trade offs by designing and prototyping systems/subsystems or simulate the functionality of these systems/subsystems so that the best alternative/s can be chosen
- Communicate sets of possibilities through matrix reports that contain evaluation of all the alternatives

Integrate by intersection

- Choose the solution that is acceptable to all. This will be visible through matrix reports that allow the intersection of feasible sets to be visible.
- Impose minimum constraints on the functional areas so that there is flexibility to choose the best alternative/s and make the best compromises.
- If a product is made that is conceptually robust, i.e., fits with all the available alternative solutions then it should proceed without waiting for other designs to be ready. This can also help collapse development time.

Establish feasibility before commitment

- All the opportunities and constraints must be fully understood before commitment is made to a certain design.
- As the concept possibilities reduce, the amount of detail within the remaining possibilities should increase as designers' work to further narrow down the possibilities.
- The designers are expected to stay within the sets committed to, so as to allow the other team members to proceed without concern for change that can cause rework.
- Toyota manages uncertainty by managing the expectations at each of the process gates in the development process. For example, high uncertainty items like transmissions are decided at the vehicle concept stage gate (pre start up phase in the development process) so that the uncertainty is dealt with early on in the process.

Iansiti's (1995) discussion of the traditional and flexible product development processes appears to be at a more theoretical level. In organisations making complex products such as cars and aeroplanes, there could be a mixture of products requiring both traditional and flexible development processes. Thus it appears that specifications will have to consider both the parts that need a flexible development process and parts that need a more traditional development process. However, the models of specification indeed give a structure as to how the specification is created. This could be utilised in order to further develop the concept of how the role of the specifications can be managed for integrated outsourced development, as the models do not include suppliers and are made for in-sourcing. The lack of a specification model for outsourcing indicates the need for research into developing a model conceptualising the role of the specifications.

2.4.2.3 Creation of Common Goals

Reinertsen (1997) claims that the creation of a strategy is the key context in which specification work is done. The products developed and produced are a critical part of the strategy and as such the product choices must fit with the rest of the strategy. In other words the product specifications must be in line with the strategy of the company which should be uniting the needs of the different departments together. Burnes & New (1997) also support this as they claim that buyer supplier relationships at the strategic level are not always the same at the operational level thereby, leading to supplier developed products that are not planned. In other words, if the OEMs do not have the same understanding of the suppliers' contribution at all levels then the supplier may be over or under utilised. Burnes and New (1997) through in-depth case studies in the Rover Group (automotive manufacturer) and TRW (Steering Systems Supplier) in the United Kingdom observed that buyer supplier relationships are initiated at the strategic level but often played out at the operational level. In other words, though this may lead to a partnership style relationship at the operational level the same cannot be said about the relationship at the strategic level as mistrust and animosity can still grow at this level. Burnes and New (1997) stress that the buyer supplier relationship can only survive if the strategic interests of both parties and operational benefits of both parties can be achieved.

The research program initiated by A.T.Kearney and Manchester Business School (1994) demonstrate similar results. They demonstrate that relationships at the operational level can be more open and collaborative than relationships at the strategic level since, strategic integration requires that the buyer supplier firms have complementary goals. Burnes and New (1997) emphasise that close working relationships at one level do not mean close relationships at other levels. In other words, suppliers may have a close working relationship at one level and not at the other levels, which could lead to a lack of focus on the expectations from the supplier. Burnes and New (1997) elucidate that it would be counterproductive to maintain close-working relationships at all levels and at the same time also emphasise that strategic initiatives must be owned by the operational staff if they are to be successful. The above two statements appear to be confusing, as unless there is a common goal at each level with respect to the supplier, the strategic initiatives will never be accepted by the different levels. This is also corroborated by Bowen et al (1994) who elucidates that subjectivity in operational decision making (in product development) can be reduced by the creation of an overarching vision. The vision, according to Bowen et al (1994), focuses the organisation on the future, serves as a concrete foundation for the organisation and also as a focal point for current decision making. In other words, if one is to benefit from the suppliers' involvement in product development we need to have a common vision about our suppliers. Further, it is important to develop the visions for suppliers else outsourced product development could be at risk. Karlsson et al (1998) suggest that the creation of visions for suppliers can help create a common understanding of the suppliers' contribution throughout the OEM. The existence of visions for suppliers would be the starting point for any specification work to be undertaken and as such can help focus the OEM on the suppliers' capabilities and capacities and thus involve the suppliers accordingly. I will begin with a review of visions.

2.4.2.3.1 Visions

In order to reduce the subjectivity in operational decision making and make the contribution to knowledge and capabilities from development projects more explicit, a guiding vision is imperative for efficient product development (Bowen et al, 1994). They argue that a vision should focus on the future, serve as a concrete foundation for the organisation and serve as a focal point for current decision making. An overall definition of a vision is the combination of the mission, the strategy and the culture of a company (Lipton, 1996). Visions emphasise what must be accomplished and why, but allow for individual interpretations of how to reach the goals (Bowen et al, 1994). They identify three different kinds of guiding visions in product development, the *line of business guiding vision*, the *project guiding vision*, and the *product concept*:

- A *line of business vision* could be a statement such as "to beat the major competitor", or "to be a low cost supplier". These can readily translate into innovation and capability development. In order to beat the major competitor or to be a low cost supplier, the company might be required to develop a new technology, certain organisational and/or individual skills, or a new information system, for example. Thus, these visions translate into what to do for the product development teams. Besides serving as guidelines for the product development teams, line of business guiding visions should be owned and understood by everybody.

- The *project vision* guides the members as to what learning must take place in order to achieve the goals defined by the line of business vision; what to learn from the project so that follow on projects will run smoothly and so as to enhance internal capabilities. This vision needs to integrate across functions and time, thus ensuring consistency and inter-functional learning. It will also lead to confidence-building so that with each decision everybody knows where they are going.

- The *product concept* links the line of business vision to the daily decisions made by the developers. It helps the developers capture the perception of what the product means to the customers. The product concept should be complete, i.e. capture all successful user experience, it should be constant, i.e. target a set of customers, and it should be visible to everybody in the organisation, i.e. it should unify the people in the organisation. I extend the product concept to all the individuals connected directly or indirectly with the development and thus rename it as the individual vision. It is not only developers that can utilise the visions but rather all the individuals in the organisation.

According to Kotter, (1996), a vision statement should be possible to present, describe and transmit in less than 5 minutes, else the company is in for trouble. Furthermore, he argues that firms fail if they allow too much complacency, underestimate the power of visions, under-communicate the visions (for example failing in getting a message across to the entire organisation), or permit obstacles to block the vision. Bowen *et al* (1994) argue that visions do not need to originate at the top of the corporate hierarchy, but can spring from creative minds anywhere in the organisation. If this is true, these signals must be captured, analysed, and developed which includes spreading them to all concerned actors and integrating them in a company's organisational routines.

To sum up, visions should provide the link between strategy and operations by setting targets that ensure strategic development and competitive advantage, simultaneously guide the plethora of operational decisions, and allow for enhancement of skills, knowledge and capabilities. A guiding vision is a clear picture of an operational future, an organisational or project destination that serves as a referent and focal point for decision making (Bowen et al, 1994). Making parallels to learning theory (Kim, 1993), the visions thus play an important role in managing the creation, evolution, and modification of individual and collective mental models of product development work.

The changing role of suppliers in the automotive industry, that intervenes as a consequence of outsourcing and black box engineering, means important integration between buyers and suppliers in product development (Clark & Fujimoto, 1991; Karlson, 1994; Quinn & Hilmer, 1994). For example, supplier engineers participate as guest engineers on project platforms (Midler, 1993; Gong, 1993), or engage in very frequent and broad banded communication with their counterparts in customer firms (Söderquist, 1997). This development can be described as a form of quasi-vertical integration: ideal relationships should be characterised by longevity, closeness and exclusivity (Richardson 1993). If suppliers are to be considered as extended families by the OEMs in order to utilise the competencies and capabilities of the suppliers then visions may not only have to be vertically articulated within the company but also horizontally articulated between the buyer and the supplier. The interesting question that arises is on how the visions for suppliers can be created and deployed? Visions once developed can be used to execute the resources that exist within the buyer/supplier or are common to both and thus positively impact outsourced product development. If resources are to be executed then capabilities and core capabilities are affected. But before that I will explore the expression "visions for suppliers" in a little more depth. The way in which the different suppliers are to be treated might require a common set of shared meanings or in other words a common culture. Now, I will explore the term culture in depth.

2.4.2.3.1.1 Culture

Culture governs how members of an organisation behave (Robbins, 2000). Organisational culture refers to a systems of shared meanings held by members that are key in distinguishing one organisation from another (Schein, 1985). In other words, if the OEMs want some of their partner suppliers to be an extension of their own organisation and develop complex parts, then the same shared meanings must be held by both the OEM and the partner suppliers. Reilly et al (1991) suggest that there are seven elements that characterise and organisation culture:

Innovation and Risk Taking: The degree to which the employees are encouraged to be innovative and risk taking.

Attention to Detail: The degree to which employees are expected to exhibit precision, analysis and attention to detail.

Outcome orientation: The degree to which the management emphasises outcomes rather than the means to achieve the outcomes.

People Orientation: The degree to which the effect of outcomes on people is taken into consideration.

Team Orientation: The degree to which work is organised around teams rather than individuals.

Aggressiveness: The degree to which people are aggressive and competitive rather than easy going.
Stability: The degree to which organisational activities emphasise the status quo as opposed to growth.

The above elements indicate the need to have a common understanding between the OEMs and the suppliers. For example, if the OEM wants to be innovative and risk taking and the supplier wants the contrary then there will be problems if they are matched up. The OEM will never be able to get planned products desired from such a supplier. The same logic can be applied to the other elements. A further example would be that in integrated and complex projects (Soderquist & Nellore, 2000) there is a need for joint work between the OEM and the supplier. If the culture is different between the OEM and the supplier, then this may be difficult to achieve and thus, the complex product may not be realised.

Organisational culture is expected to represent a common perception held by the organisational members (Robbins, 2000) as culture is shared meaning. It is thus important that individuals with different backgrounds describe the organisational culture in similar terms. This becomes all the more important as without dominant cultures (where the core values are shared by a majority of the members of an organisation) there will be no uniform representation of appropriate/inappropriate behaviour. For example, if Purchasing and Engineering do not share the same dominant values, then the suppliers might be treated in different ways leading to confusion and problems. The OEMs need to present a single voice to the supplier and the supplier should have the capacities and capabilities to implement the single decision voice with total commitment. This could mean that there needs to be a match between the two cultures of the buyer and the supplier. A strong culture is characterised by the organisations core values being intensely held and widely shared (Wiener, 1988). This is not only limited to OEMs but also to the supplier base so that the suppliers may have to be treated uniformly by the OEM. This is important given the fact that the suppliers should have the skills set in order to generate the planned products.

Culture is a liability when the shared values do not agree with those that will further an organisation's effectiveness (Robbins, 2000). Consistency of behaviour is an asset in a stable environment but can hinder an organisation's ability to respond to rapid changes. This makes it all the more important to continuously asses the culture not only internally but also in the supplier base as developmental activities are also carried out by the suppliers in outsourced product development.

2.4.2.3.2 ***Core Capabilities***

Bowen et al, (1994) emphasise the need of specific core capabilities in order to achieve the visions. Conversely, Söderquist (1997) found that visions intervene as decisive factors in the process of building core capabilities. All the different resources in a company, including visions, are potential inputs to the core capabilities. Hence, there is a reciprocal interdependence between visions and core capabilities.

According to Bowen et al (1994), Grant (1991) and Stern (1992), capabilities are composed of basic resources (such as capital equipment, individual skills, and product and process technology), managerial systems (such as decision procedures and career development schemes), physical systems (such as information systems and technical support systems), and values (such as the status of different functional disciplines, or what is considered to be priority). Core capabilities are those that are grounded in a firm's resources and differentiate the firm from its competitors (Lacity et al, 1992). Through dynamic visions and learning processes the evolution of a company's core capabilities should be a perpetual process towards ever-new distinctive competitive advantage (Söderquist, 1997). Different projects -corresponding to different visions- may require different capabilities and hence there must be a match between the visions and existing or emerging capabilities (Bowen et al, 1994).

A major problem, though, is that core capabilities can easily turn into core rigidities. For example, lower status for non-dominant disciplines could mean that people working there are not listened to. Empowered and skilled people within such disciplines may then feel offended and leave the company. This might lead to a lack of particular skills needed in projects. Sometimes, outdated physical systems may live their lives creating obstacles, for example obsolete testing systems that are too slow. The management systems can lead to rigidities as well. For example, if there are no clear career paths for project leaders or project workers, skilled people may shun these jobs and focus on a functional career within different technical disciplines. Bowen et al (1994) propose that the right visions might hinder core capabilities to turn into core rigidities. The discussion on core capabilities is within an OEM and since I am concerned with outsourced product development it would be interesting to observe the effects of core capabilities on the relationship between an OEM and the supplier. Given the reciprocal dependence between core capabilities and visions it would be appropriate to consider the joint effects of core capabilities and visions for suppliers on the OEM – supplier relationship.

2.4.3 Stage 2 elements

In stage 2, the topics to be discussed will be on the requirements of specifications, the customer benefit connection to specifications, the technology effects on specifications and the traps that are to be avoided in the specifications.

2.4.3.1 Requirements of specifications

Roozenburg & Dorst (1991) define the requirements of a good specification. According to them, a specification should possess five virtues. They should be comprehensive, i.e., there must be a clear understanding of the requirements and the information supplied by the normative statements[40] should be complete. It should be operational, i.e., the specification must have the same meaning to all in the design team. Also the requirements in the specification should be measurable in quantitative terms. The specifications should not be redundant. That means that there should be no double counting of the same properties in the design evaluations. The specifications should be complete in all respects and lastly, the specifications should have minimum size, as the evaluation of the design proposals becomes difficult with the increase in the number of criteria. Fine & Whitney (1996) have also studied the requirements for specifications in the aerospace industry where the specification process is also called systems engineering and referred to as a top-down design process. According to them, an important lesson from system engineering is that a good specification and decomposition leads to a good product design. In each stage

[40] Customers express their needs normatively.

of the system engineering process there are skills that are needed, such as the ability to determine the needs above (i.e. the customer), to break these needs up into supporting capabilities and specify these capabilities to the suppliers, who will then deliver them after the development. Not every item is totally decomposable, i.e., can be described without any interfaces, though the totally decomposable items are the best candidates for outsourcing.

It appears that there are many requirements on the specifications. The requirements will have to be considered when creating a specification or communicating one. Without imposing certain requirements on the specification, the specifications could turn out to be incomprehensible[41]. These requirements would be helpful when communicating the specification and the parameters that it contains so its role is articulated in a succinct manner. Currently there is no ISO standard for writing a specification and these requirements could be beneficial in attaining certain standards while writing specifications.

2.4.3.2 Customer (OEM) benefits and specifications

There must be a focus not only on the product, but also the customer (OEM) benefits that the product is supposed to give (Smith & Reinertsen, 1991). It is important, during the specification writing, to focus on what the customer perceives as a benefit and then make the trade-offs. For example, in the specification writing for a printer, it must be considered that the customer might want the printer to be compatible with his current office automation, which could have been supplied by other suppliers. If this is not done, i.e., a customer benefit is not focused on, then there could be losses.

Specifications are of vital importance, as they could affect the development process and the product as well. For example, a badly designed specification can delay the start of development and/or increase the time to start of production. According to Smith & Reinartsen (1991), many companies simply write specifications for the sake of writing them and never use them as working documents. People are more concerned with having a piece of paper called the specification. They use it as a tool

[41] Many OEMs want their suppliers to be ISO9000 accredited. The accreditation allows the suppliers to follow standards that facilitate common understanding and improvements in productivity.

to prove their innocence if things go wrong, instead of incorporating customer benefits and using the specification as a working document. Specifications are not the end but just the means to the end. Therefore it is necessary not to delay the specification writing, even if all the required information is not available (Smith & Reinartsen, 1991).

2.4.3.3 Technology effects on specifications

In order to understand the technological effects, the industry movement - specification link with respect to the computer industry will be examined at first. The situation of IBM, DEC, etc., has been described by Fine (1998). During the early 70s, the vertically integrated systems suppliers dominated the computer industry and IBM dominated virtually every aspect of the industry. They needed to be the best in all the sub-systems so as not to lose customers. In the late 70s, IBM's personal computer division broke away from the tradition and used a modular architecture, i.e., the operating system came from Microsoft and the microprocessor from Intel, etc. This created a horizontal industry structure where there was sufficient competition within each system that made up the entire computer. With competition becoming cut throat, Intel and Microsoft started penetrating other segments/systems, as the industry was no longer stable due to the competition. One question that arises is on whether the extent of supplier involvement (vertical/horizontal industry) would affect the content of the specification?

The learning for this research project is that the content of the specification should reflect on, the involvement of external parties. For example, a completely tight specification (as in a vertical industry) cannot be given to a supplier with a high knowledge content when outsourcing (as in a horizontal industry). This problem can be observed when large suppliers are over-managed, leading to chaos in the development process. The specifications need to reflect the industry and changing conditions. Apart from reflecting the industry, the specifications could also consider the amount of information that must be given to the supplier or obtained from the supplier in case of outsourcing, as systems/components do not work in isolation in the automobile. They need to work together and hence it is of utmost importance that these items be interfaced with each other. Therefore, when suppliers develop products[42] the specifications should consider whether there should be a transfer of relevant technology to the supplier. There are basically two types of technological knowledge transfer, namely components and systems knowledge transfer (Aoshima, 1993). Components can be further classified as independent and systems components. A simple component such as a wiper can be developed in isolation and does not have any effect on the development of other components. On the other hand, in order to assemble a HVAC (heating ventilation and air conditioning system) one would need knowledge about the other items that it needs to be interfaced with, as it is a dependent system. This means that in a systems transfer, knowledge of how to combine the HVAC with other parts needs to be communicated. This is a system transfer, which is indeed the most difficult.

The product status helps the managers to understand and emphasise certain aspects of the specification more than others. For example, when to have straight carryovers as opposed to developing completely new specifications/products all the time. The concept of product status is defined and used extensively by Hollins & Pugh (1990) as a tool to direct the design managers. Hollins & Pugh (1990) describe two kinds of product status, namely, the static and the dynamic. Products are said to have a dynamic status when the design changes are of a radical nature and changes occur in the basic concept. Products are static in status when the changes are incremental and the basic concept is unchanged. It is important to remember that the products can have static and dynamic status, i.e., the status can change. The key to managing the specifications is to correctly estimate the product status so that suitable design changes can be emphasised. This can also lead to the correct focus on design, marketing and production. For example, if the design is dynamic, then patents are more important than standards. Wasti & Liker (1999) point out that in the case of dynamic designs (which have high technological uncertainty) there is a positive association with the level of supplier involvement, i.e., the higher the technological uncertainty, the greater the level of supplier involvement. Knowledge of the product status will help companies to decide when to develop new technologies. Hollins & Pugh (1990) comment that if the product specification is the best available within a

[42] Products could mean systems, components, etc.

certain technology then the product design is unlikely to change[43] as is the case with restricted product design. Huge investments in machinery can make a product static as the investment is based on the estimation of a certain volume. A product will be static if it has a large number of interfaces and so will limited design time, according to Hollins & Pugh (1990), as the designer will be forced to use the existing tools. The concept of product status can have an impact on the relationship between the buyer and the supplier as can the type of specification allocated to the supplier.

The above discussion can also be related to the problems that companies faced with respect to the role of the specification that they gave to their suppliers when moving from total insourcing to outsourcing of various degrees. In outsourcing, the specifications cannot be same as those developed during insourcing. The understanding of this difference is an important component for both the buyer and the supplier in understanding the term specification in the same manner and also in linking specification to the technology. In other words, there would be a change in the technology transfer when there is a system transfer as opposed to a component transfer. The concept of product status appears to be important when communicating the role of the specification as how else would the OEMs know as to when the technology would change in systems or components that they outsource? The change in the role of the specification when moving from outsourcing to insourcing and vice versa is a potential problem area that may have to be dealt with in trying to manage the role of specifications.

[43] This has its advantages and disadvantages. The advantages are that the staff can concentrate on areas that are changing and not on areas that are static. The disadvantages are that the technologies might change with out the form being aware of it leading to competitive disadvantages for the firm.

2.4.3.4 Traps and specifications

Companies fall into a trap when developing a list of performance specifications for a new product. This is called the best of best specification trap (Rosenau, 1992). This problem is typical when a company's specifications are based on the single best features of the competitor. Thus, the new product design is driven by competition and not by market insight. Delays can be created in the product development process when there are rumours of competitive changes as the specifications will have to be changed. This problem can occur when the marketing people have a sales background (Rosenau, 1992). A sales person would want to sell a product cheaply in order to meet his quota whereas a marketing person would devise ways and means to sell the same product at a premium. When the reward is on profit and not on sales, the marketing people with a sales background are in a quandary. A marketing person with a sales background would try to generate a specification which equals the best amongst the competitors and then try to sell it for a price lower than the least proposed by the competitors. On the other hand, a person with a marketing background would try to generate a specification that tops all the others, includes competitive advantage features, is customer driven and then try to get a price premium for it.

If specifications are written solely by marketing, then the features emphasised by them would be based on the present customer needs. On the other hand, the engineers would like to experiment with new technology and make new discoveries. Manufacturing people have to work out the bugs in the new product. A good specification can only be generated by the combination of these different kinds of knowledge. There should only be one document called the specification and it should be created by the joint labour between the different parties and there should be no separate specifications (such as one from each department), according to Smith & Reinartsen (1991). There needs to be a joint participation in the writing of specification, as no single person or department knows everything. The balance between the different trade-offs is the mark of a good specification.

Avoiding traps can help to achieve planned products. There could be numerous traps beyond those suggested by the authors. It is also necessary to come to terms with as many traps as possible so that they can be avoided as far as possible. Traps certainly fall into the category of problems experienced by companies, which necessitate examination. The above discussion points towards examining the different problems that are faced with regard to the role of specifications.

2.4.4 Stage 3 elements

The following discussion will centre on topics that have been given the least attention in specification literature. These topics concern the capabilities that are required for specifications and the different trade-offs that could be made in the specifications. These elements have been given the least attention in specification research and thus form the outer core for the current literature organisation.

2.4.4.1 Capabilities and specifications

There are certain important capabilities required by the buyer and the supplier in the specifications (Wheelwright & Clark, 1993). They state that from the point of the buyer there are three major capabilities, namely the ability to create downstream friendly solutions, quick problem solving and error free design. In the first case, there must be an attempt to take into consideration the limitations and capabilities of the supplier. However, excessive consideration for the supplier capabilities can lead to losses and hence there needs to be a trade-off. Time is money and errors can increase both time and cost. For a variety of reasons, it is crucial to have error-free designs, as this decreases the number of loops required to solve the problems. Errors detected at a late stage can require substantial changes for the suppliers and thus lead to increased costs. There should be an emphasis on fast problem solving. Problems arising from the suppliers end need to be resolved as soon as possible. For this reason, having short feedback loops can prove to be very beneficial.

The suppliers are also required to possess certain capabilities, namely the ability to forecast from the buyer clues, manage risks and cope with unexpected changes, according to Wheelwright & Clark (1993). In the first case, the supplier must have the capability to understand the clues from the buyers, for example, to develop and propose solutions when they are worried about certain items in a design. The second is to manage risk, in other words, to balance the trade-off between the risk of design change and an early start. For example, the suppliers can design parts that are least likely to change and work less on areas that are most susceptible to change. The third ability is to react to unexpected changes and develop solutions faster. Different contingencies must be thought of, as speed is very essential in integrated problem solving. The supplier must have the ability to design fast solutions.

In integrated problem solving, the top management can play a facilitating role, (Wheelwright & Clark, 1993). For example, a visual display of problem solving between the buyer's and supplier's top management teams can prove to be a guiding force for the remainder of the organisations, both for the supplier and the buyer.

As stated earlier, the product development tasks cannot be performed by an individual/firm, but rather need to be divided between individuals and firms so that they use each other's expertise. It can be concluded from the above discussion that both the suppliers and buyers are required to possess certain capabilities for understanding and interpreting the specification. Doing this will allow a specification - supplier match. If there are no capabilities and the specification cannot be managed with the existing ones, then there are bound to be problems. Not having capabilities or capacities and the reasons behind this could be helpful in understanding the underlying problems faced in the role of specifications. This understanding could help develop processes to improve the integration between the buyer and the suppliers.

2.4.4.2 Trade-offs and specifications

Specifications are hard to write and according to Smith & Reinartsen (1991) there are many reasons for this such as:

- Many times the crucial elements in a specification are hard to put into writing or into quantitative terms.
- Pure narrative statements are hard to understand and, as far as the engineers are concerned, not all information can be attained before the design start.

- Information that should have been in the design is obtained after the design start.
- Difficulties may arise because of the interaction between various elements in the specification.

The interaction problems can be explained through an example[44] concerning the height and processing capabilities of a food processor. The designer will have to read between the lines to make the best trade-offs. He cannot simply rely on the single point statement in the specification, but rather on the combination of values that suits the user even better. For example, the specification could read as follows: The machine should be taller as it will process food better. There are many questions that arise from the above statements for example, how tall should the machine be? What is better processing? etc. The designer has to read between the lines and have detailed discussions on the specifications in order to make the necessary trade-offs. If the specification writers concentrate more on things that they can easily describe or things that they understand instead of matters that are hard to describe or understand, then the specifications will be hard to achieve. However, specification writers must force themselves to understand and describe the crucial elements as well.

It is apparent that specifications are the outcome of trade-offs between different factors or parameters. The writers must not only describe the easy elements, but also the elements that are hard to visualise. This means that the specifications may have to consider these if they are to overcome the problems that are inherent in the specifications. If problems are present, then ways and means may have to be developed in order to overcome them.

[44] This example has been quoted from Smith & Reinartsen (1991)

Managing trade-offs is a difficult issue. The trade-offs have to suit the customer, as otherwise the product may not sell. Trade-offs can be made in different spheres of the product, for example, in a car the trade-offs may encompass areas such as the electronics, the dashboard, etc. In particular, if a navigation system is to be installed in the car, then the dashboard may have to be in a slanting position. Some customers may not like it. However the trade-off will have to be made between the slanting dashboard and the navigation display. This trade-off may require the wire harness supplier to investigate, as the wire harnesses may have problems in routing. What is being emphasised is that there are different departments that may have to make the trade-offs and hence there is a need for a common forum where all the possibilities can be written down and discussed. It provides an ideal setting if people are willing to change their attitude towards specifications and consider it to be a working document instead. Not making trade-offs in a rational manner may result in problems in the specifications. If trade-offs in the specification can cause problems, then it may be interesting to observe the effects of these problems on the role of specifications and then find means to overcome them.

2.5 Conclusion and Research Questions

A wide range of factors may have to be considered while dealing with the role of specifications. If the specifications are not generated with the necessary parameters and processes, then both the OEM and the suppliers may have to bear the consequences of customer disenchantment with the product due to delays in product introduction, poor quality, expected innovation levels, etc. This could lead to losses both for the OEM and the suppliers and underlines the need for an integrated approach between them. Suppliers are increasingly becoming members in the management of the information asset of OEM and the OEMs are now looking towards managing what they are best in, i.e., the whole car. If suppliers are to take an increasing part in the information asset, then they will be interacting with the OEM in the different stages of the information asset framework. The above literature review has indicated the lack of research in six key areas, as far as the role of specifications is concerned. The detailed research questions that will attempt to contribute by examining these areas are as follows:

1.	*What are the different elements that can be contained in a specification?*
2.	*What are the impacts of the network of suppliers on the role of specifications?*
3.	*What are the issues faced by OEMs with regard to the role of specifications?*
4.	*How can visions for suppliers be created and deployed leading to a positive impact on outsourced product development?*
5.	*What are the possible impacts that visions for suppliers may have on the core capabilities of an organisation?*
6.	*How could the role of specifications be illustrated with the help of a conceptual model?*

2.6 Contracts - An Overview

As articulated in the introduction chapter (1), contracts are being projected as an important management tool in order to validate the specifications. Theories that focus on the division of activities between firms often propose two governance modes for transactions: to internalise through vertical integration (hierarchy), or to externalise to suppliers (market) (Williamson, 1979). Vertical integration is preferred when assets are highly specific, when uncertainty surrounds the transaction, and if such transactions occur frequently (Williamson, 1979). Externalisation is preferred under the opposite conditions.

Contracts are associated with the market mode, where firms meet to exchange goods with low asset specificity under conditions of low uncertainty (Teece, 1987; Lieberman, 1991). As long as contracts will be able to cover all possible contingencies in the transactions, markets are seen as the optimal governance mode (Lieberman, 1991). Parties reaching an agreement or deemed to have reached an agreement are said to have made a contract (Major & Taylor, 1996). The agreement can be done in writing, in verbal, and by inference from the opposite party or parties (Major & Taylor, 1996).

Major & Taylor (1996) observe contracts to have three fundamental elements, namely the agreement, the intention, and the consideration:

- Agreement is reached when there is existence of a clear offer and acceptance of that offer.
- Intention is the need to create legal relations to protect the interests of the concerned parties.

- The consideration or understanding is arrived at when the parties have reached a scenario of exchange of benefits and losses.

There is some important literature on the use of contracts as legal documents for commercial purposes in a market situation referring to the transaction cost framework (Major & Taylor, 1996; Teece, 1987). As the present research focuses on the intermediate mode, I turn to literature dealing specifically with the role of contracts in outsourced product development where specifications are developed in collaboration between buyers and suppliers.

An intermediate situation, quasi-vertical integration, has been developed as a governance mode in its own right Turnbull & Valla, 1986; Hakansson, 1982). In this mode, the relationship is the focal point of interest and "firms gain the advantage of vertical integration without assuming the risks and rigidity of ownership" (Blois, 1971).

A contract is used in a market mode as the major mechanism for ensuring that the business takes place under conditions of mutual benefits for the buyer and supplier. Contracts are generally not used in a hierarchy mode, as the latter is internal to the OEM (Teece, 1987). However, a central question is whether contracts can be used in the relationship mode? Crocker *et al* (1998) argue that contracts cannot cover all the contingencies in this mode, due to the intricate interdependencies between all the firms. Instead, he joins the argument of Cooper (1975) that contracts can be used as a *forum* to create an optimal relationship and ensure that the parties (suppliers and buyers) perform what is necessary when it is necessary. This argument is also supported by Adler (1999), who elucidates that compared to trust, price and authority are relatively ineffective mechanisms when dealing with assets based on knowledge. In other words, the complex products based on knowledge that are interchanged between the buyer and supplier in the automotive industry need trust to serve as a governance mechanism. Adler (1999) cautions that this trust is reflective and not blind. The reflective trust ensures that there are rules to ensure stability and equity, and competition to ensure flexibility and opportunity. Trust is important in the relationship mode (Sako, 1992). However, trust is a cognitive - emotive result of experience with someone or something, making it very difficult to set targets and ultimately evaluate whether a task or activity has been realised according to expectations. Contracts could be seen as means for validating that tasks and activities are executed as presumed in a buyer-supplier relationship based on trust and in other words support the argument of reflective trust proposed by Adler (1999).

The research question aims at analysing the role and use of contracts in the relationship mode between buyers and suppliers in product development. Outsourcing is becoming an important strategy in many organisations (Harris et al, 1998). Thus, the importance of contractual arrangements accompanying outsourcing is also growing (Helper, 1995). In order to operationalise the analysis of the use of contracts, I relate contracts to the specification flow between buyers and suppliers engaged in joint development.

Before I go any further into the literature review[45] on contracts, the detailed research question[46], which will emerge after the literature review, will be laid out in order to help the reader.

7. What is the role of contracts in assisting the validation of specifications in the development process?

The methodology followed in this section is the same as that used on the topic of specifications. In other words, the bibliometric method is used here that allows us to pose questions about the conclusions. I will recap the important steps that are to be followed in the bibliometric method as follows:

- List the most representative sample of authors in the specification literature
- Identify the message that these authors intend to convey
- There is bound to be error/inconsistency in the interpretation of the content variables

[45] When the author conducted a search for literature on the topic of contracts there were a number of references that were obtained. In order to rank the references in some order of importance, a literature search was conducted to find out as to how the references could be assessed and thus, emerging questions reflected on. The literature search obtained an article on the organisation of operations management literature, which was then used as a basis for the organisation of the section on specification literature.

[46] The detailed research question emerges after a full literature search.

- Identify the content variable most frequently mentioned
- Draw concentric boxes to identify the most popular content variable and map it to the least popular concentric variable. This will also help identify the less researched and most researched variables.
- Comment on each of the content variables and their applicability to the research question. Identify possible drawbacks in the current literature so that the research questions can have a firm base in current literature.

The literature analysis on specifications begins with the list of authors and the content variables as shown in Appendix 8. After this, the concentric boxes are drawn to identify the most popular topic as opposed to the least popular topic. This is represented in Figure 2-3. The most important content variables are listed in Stage 0, followed by Stage1, and Stage2. The literature review will be structured in the same way. First I will discuss Stage 0 and then continue sequentially until Stage 2.

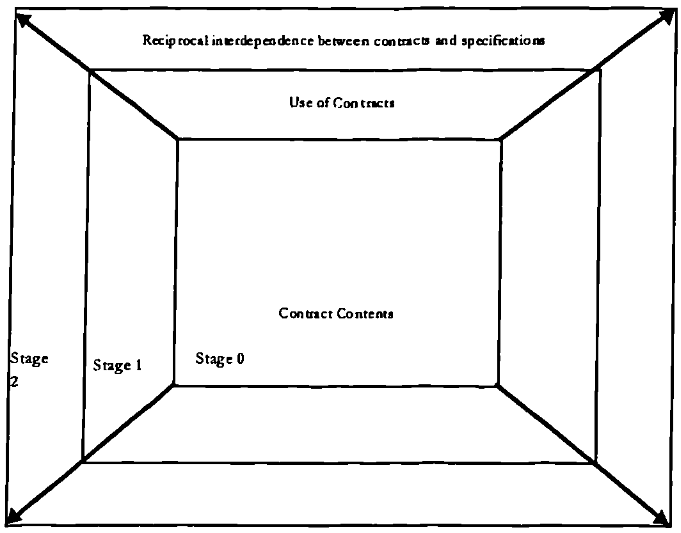

Figure 2-3, Content variables making the core and outer boxes

2.6.1 Core elements: Stage 0 – Contract Contents

The core elements are those topics that have received the most attention in contract research in the automotive industry. Only one topic, namely the content of contracts, has been observed to be contained within the core elements.

The literature on the validation parameters is mainly grounded in purchasing. In outsourced product development the suppliers and buyers do the work in varying degrees of collaboration (Lamming, 1993). Besides focusing on *product* validation, it is important that OEMs validate that the suppliers have the *capacities* and *capabilities* to remain sustainable partners, particularly if they are to take a major role in the OEM development process (Lamming, 1993). In other words, contracts can contain criteria specific to the product and also criteria specific to the suppliers who are to execute the specifications.

Today, all OEMs conduct extensive capability audits before selecting suppliers, and also regularly audit suppliers in ongoing relationships (Kolay, 1993; Monszka et al, 1995). These audits might concern the contribution to product development, technological capability, innovation capability, contribution to the OEM product advantage, use of total quality management, potential for further improvement, potential for price reduction, suppliers financial stability, management commitment to excellence, flexibility, cost competitiveness, cycle time concentration and manufacturing skills (Cash, 1996; Harrison, 1990; Hyun, 1994; Kolay, 1993; LaLonde et al, 1994; Larson, 1994; Levy et al, 1995; Mohanty et al, 1993; Monszka et al, 1995; Turnbull et al, 1986). Payment terms were also considered to be important in source audits (Leenders et al, 1993). All parameters considered relevant by the OEM are susceptible to be contained in the contract. The different performance criteria for suppliers may be considered in advance if an OEM wishes to make a useful contract that can reduce tensions with suppliers and at the same time keep the relationship working. The fulfilment of goals relative to these criteria is expected to improve the relationship thus leading to partnership.

The above identified validation criteria can be regrouped into levels of importance in order to support the validation of specifications. The study will explore how validation criteria can be integrated and used in contracts as a means of assisting the validation of the specifications.

Kanter (1994), studying partnerships within the framework of alliances (i.e. long/short term collaboration between firms and other organisations involving partial/contractual ownership which are developed for strategic reasons (Forrest, 1989), argue that there should be strategic integration (goals, objectives), tactical integration (to develop plans for projects), operational integration (working procedures), interpersonal integration (meetings, conferences), and cultural integration (learning each others culture) at all levels in an organisation. This typology consists of an interesting benchmark for the anticipated findings of the present study.

2.6.2 Stage 1 elements – Use of Contracts

The stage 1 element or topic of discussion is on the use of contracts in outsourced product development. This topic is next to the core elements in order of importance.

Asmus & Griffin (1993) argue that best practice procurement requires optimisation of three major elements of the supply management process, namely product development/specifications, sourcing, and contract execution:

- Product development/specifications concerns the link between R&D, engineering, and suppliers. Suppliers who will be given development responsibilities need to be selected before product engineering starts so that they become an integral part of the product development team. These suppliers must be capable of leading new technology development. These affirmations are shared by the product development literature (Schilling et al, 1998).
- Sourcing concerns the overall determination of the number of suppliers to work with, supplier auditing and selection, and determination of contractual agreements. Sourcing refers to the core activities of the purchasing department (Dowlatshahi, 1992).
- Contract execution relates to how OEMs will work with their suppliers on a day to day basis. For example, Honda has dedicated teams at its suppliers to reduce costs.

Asmus & Griffin (1993) discuss specifications and contracts independently of each other and do not explore the linkage between them. Cooper (1975), on the other hand, argues that the negotiation of contracts is a central part of strategic planning in purchasing. Taking the example of the construction industry, he suggests that contract negotiation process can be used as a forum to raise and answer questions that need to be the object for negotiations before suppliers are chosen. The objective of these negotiations is to validate that the suppliers are capable of fulfilling the demands that are imposed on them by the specifications.

The notion of validation merits further investigation, as Cooper does not state how validation will be performed during the course of the business. Moreover, there is no consideration of the link between contracts and specifications. My working assumption is that all establishment and modification of contracts has to refer to the specifications, as the latter are the ultimate references that suppliers are expected to satisfy.

There are also risks related to contracts. Companies signing long term contracts with suppliers within the framework of outsourcing run the risk of paying the supplier for extra contractual charges and of getting stuck with old technology when the technological environment changes (Harris et al, 1998). If contracts have flexible options, such as early termination, incentive contracts, price flexibility, re-negotiation flexibility and flexibility in terms of duration, these problems could be reduced. A certain flexibility in the contracts would be necessary in order to keep up with the evolution of specifications that takes place in integrated product development between buyers and suppliers (Harris et al, 1998).

Although the importance of contracts in outsourcing is emphasised in the literature, there is very little discussion of their role in assisting the validation of technical specifications. If flexible contacts with a clause for early termination are used, the OEM can remove a supplier from business if the supplier does not supply the "right" technology. However, removing suppliers instead of helping them to improve themselves would mean non-continuous evaluation of the specifications which could lead to a spiral of late design changes and a risk of modification of related components and systems. Thus, flexible contracts do not solve all problems. Rather, contracts might have an important role to play in terms of *continuous* validation of supplier performance compared to the evolution of specifications in order to avoid such drastic actions as removing a supplier during the course of a project.

As I have argued, specifications are dynamic. In each stage in the process of specifying, there is compilation and adding of information, so the content of the specification is gradually extended (Karlsson et al, 1998; Kaulio, 1996, Smith et al, 1992). The validation aspect becomes all the more important if buyers and suppliers have different perceptions of their relationships like in the case of development responsibility (Arkader et al, 1998). Validation might narrow the gap between different perceptions by allowing the articulated demands to be checked for completion. Changing product development demands on suppliers and OEMs in the framework of black box engineering require new ways of working (Karlsson et al, 1998). This would, in turn, demand validation mechanisms to ensure that the demands are being fulfilled. Written contracts can form a guiding or controlling mechanism in integrated product development as they can verify that the other party does what they have promised. I will explore whether literature has explicitly stated what validation elements that can be contained in a contract.

2.6.3 Stage 2 elements – Reciprocal interdependence

The stage 2 elements focus on the reciprocal interdependence between contracts and specifications. This is the topic that ranks last in importance in the contract literature, further confirming the lack of research in the important area of specification and contract management in outsourced product development.

The analysis above instigates us to investigate the reciprocal interdependence between contracts and specifications. I will explore this further in order to position the research question better. Kaulio (1996) discusses the connection between specifications and contracts, arguing that the specification takes on the role of knowledge gathering during non-contractual situations and the role of market investigation during contractual situations. Hence, according to Kaulio (1996), the role of specification varies with the contractual situation. The contractual situation is engaged with suppliers who possess different capabilities and capacities. When contracts are developed and specifications exchanged, it might, therefore, be very useful to classify suppliers in relation to their capabilities relative to integrated product development (Karlsson et al, 1998). Kamath & Liker (1994) propose such a classification and this has already been discussed in the literature review on specifications.

If suppliers possess different capabilities, then they may perform different specification roles irrespective of whether a contract is present or not. For example, when a supplier presents concepts to an OEM, the supplier has already performed the knowledge-gathering role even though the supplier was not under contract. Hence, the contract – specification link, as explained by Kaulio (1996), has to be linked to the categories of suppliers as certain categories of suppliers may or may not follow the propositions of Kaulio (1996). If the roles of the specifications are variable, then the contract needs to reflect these variations. If the nature of specifications turn out to be very different than those in current use, then the contracts will have to be updated in order to reflect these changes. Without the contracts, the specifications cannot be satisfied, and without the specifications, the contracts are of no use as their primary purpose is to validate the specifications. In a nutshell, there is reciprocal influence between specifications and contracts.

2.7 Conclusion and Research Question

Relationships are a governance mechanism in their own right. However, the argument proposed and defended during the course of this discussion is that the relationship governance may require a guiding mechanism such as that of a contract. Suppliers are taking increasing part in testing and in various activities that are critical to OEM firms. If suppliers are to take on activities of such importance, the OEM may have to be sure that the tasks of the suppliers are validated and, in effect, what is being proposed is a strategic contract which could serve as a guiding mechanism in the product development process to validate the specifications. Once the assumptions and expectations are clear, a clear sign of movement towards integrated development can be observed. It has been observed throughout the text that the validation of specifications is important. Without the validation of the specifications the planned product will not be realised. The role of the contract will be examined with respect to the content, validation and trust. This leads us to the following detailed research question:

7. What is the role of contracts in assisting the validation of specifications in the development process?

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3. METHODOLOGY

3.1 Introduction

This chapter outlines the methodology for the research as discussed in the previous chapter (2). It analyses the methodological approach, data gathering and analysis techniques for a better understanding of the research process. A particular methodological approach in research depends on a number of factors that have to be considered in the beginning of a research venture. It is the aim of this section to shed light on these issues.

3.2 Approaches to Methodology

One way of approaching research methodology is to consider research in terms of quantitative vs qualitative approaches on the one hand, and inductive vs. deductive relation to theory on the other (Bergadaa & Nyeck, 1992 - Table 3-1)

	Inductive	**Deductive**
Quantitative	To observe specific relations between a large number of objects and describe them in a model	To determine if numerous objects that are representative of the problem at hand dispose of the properties and relationships anticipated by a theoretical model.
Qualitative	To define the behaviour of an object and to understand the conceptual framework to which it belongs. Develop theories, models etc. from observations	To explain the characteristics and behaviour of existing objects following a set of predetermined relationships in a model.

Table 3-1, Approaches to research methodology

As observed from the above table, there are four principally different research logics to choose from. In deciding which approach to use in a specific research project, several things have to be considered, for example, the philosophical position of the researcher, the research questions, the research object, the research strategy, and the relation to existing theory (Easterby-Smith *et al*, 1991; Yin, 1989).

The philosophical standpoint of the researcher and his/her institution/supervisors will largely determine the objectives of research projects and the research questions (Easterby-Smith et al., 1991). The two principally different standpoints are the *positivist* standpoint, where the world is seen as objective and the researcher is independent in relation to the observed, and the *phenomenological* standpoint where the world is subjective and the emphasis is on developing meanings and explanations from the observed data in which the observer is a part.

Recalling the classification from Bergadaa & Nyeck (1992), the qualitative inductive logic would be the core representative for the phenomenological position and the quantitative deductive logic the one for the positivist approach. Even though the positivist/phenomenology dichotomy represents two extremes and most research 'borrows' ideas and methods from both (Easterby-Smith *et al* 1991; Miles & Huberman, 1994; Silverman, 1993) the basic world-view held by an individual researcher (or institute) is an important factor for the development of a research design.

In order to elaborate further, the difference between qualitative and quantitative approaches, and the difference between an inductive and deductive relation to theory will be discussed in more depth.

3.3 Choice of qualitative or quantitative approach

An initial scanning of the literature on research methodology shows that the notion of a qualitative vs. quantitative approach is a complex one as it is simultaneously related to *data*, to *research objectives*, and to *methods* (Easterby-Smith et al, 1991; Morgan & Smircich, 1980; Van Maanen, 1983; Yin, 1990). What basically determines the choice is the *objective* of the research and, as a direct consequence of the latter, the *nature of the research questions*; is the researcher looking for *meaning and explanation* (qualitative approach) or for *frequencies and fundamental laws* (quantitative approach) (Van Maanen, 1983). This distinction is also directly linked to the philosophical standpoint. Focus on meaning is at the core of the phenomenological approach, while frequencies and facts are central to the positivist standpoint (Easterby-Smith et al, 1991).

If the objective is to search for meaning, i.e., descriptions and explanations of processes, analysis and understanding of contextual relationships, and generation or revision of conceptual frameworks (Miles & Huberman, 1994, p.1; Easterby-Smith et al, 1991, p.27), then qualitative *data* in the form of words rather than numbers should be collected (Miles & Huberman, 1994, p.1). A structured way to classify research objectives is to distinguish between exploratory, descriptive or explanatory research (Yin, 1989).

The research objective does not automatically define a qualitative or quantitative research logic. Even though an exploratory objective is almost exclusively linked to qualitative approaches with preferred methods like documentary studies, case studies and non- or semi-directive interviews, Evrard, *et al* (1993) argue that both descriptive and explanatory objectives can comprise qualitative data as well quantitative, and small samples as well as large. Thus, without having considered the philosophical position, and without further examination of the research questions, the question of quantitative vs. qualitative approach cannot be resolved.

Yin (1989) distinguishes five forms of *research questions*: 'who', 'what', 'where', "how", and "why" questions (p. 17). As argued above, the research questions strongly influence the choice between weather quantitative or qualitative data should be looked for. Yin (1989) specifies this in the following way:

- "What" questions in the sense "how much" or "how many" refer to numbers, i.e., quantitative data, and the most appropriate research strategies are surveys or archival analysis (for example the study of financial data for a large number of companies in databases).
- "How" questions, "why" questions, and "what" questions of an exploratory kind, are, on the other hand, concerned with coming to terms with the meaning, not the frequency, of a certain phenomenon, i.e., qualitative data and qualitative approach to analysis.

Recalling the research questions in the present research (Table[47] 3-2) it is observed that they are of a "how" and exploratory "what" kind, so a qualitative approach dealing with meaning rather than frequency was chosen.

[47] The main or overall research questions as identified in the introduction chapter have been broken down into detailed research questions as a result of the literature review in chapter 2.

Overall Research Question 1: What is the role of specifications in integrated development between the OEM and the suppliers? Detailed research questions: 1. What are the different elements that can be contained in a specification? 2. What are the impacts of the network of suppliers on the role of specification? 3. What are the issues faced by OEMs with regard to the role of specifications? 4. How can visions for suppliers be created and deployed leading to a positive impact on outsourced product development? 5. What are the possible impacts that visions for suppliers may have on the core capabilities of an organisation? 6. How could the role of specifications be illustrated with the help of a conceptual model? **Overall Research Question 2: What is the role of written contracts in assisting the validation of specifications in the development process?**

Table 3-2 , The research questions

In terms of *methods*, i.e., techniques for data collection and analysis (Easterby-Smith et al, 1991), *quantitative* methods should be used when one attempts to capture the world as a "concrete structure", where the social world can be treated as if in a state of immobility so that phenomena can be analysed in terms of the relationships between the elements (Morgan & Smircich, 1980). The emphasis in quantitative methods is on sample size, controlling for contingency factors, establishing confidence levels, and using statistical techniques for testing relationships between sets of data (Bergadaa & Nyeck, 1992, Easterby-Smith et al, 1991). In quantitative methods, there is a process of prediction – hypothesis making, testing, and generalisation.

Qualitative methods should be used when the objective is to look for causal descriptions and/or explanations. Qualitative methods rely on *coding* of *words* collected through observations, interviews (discourse analysis), or documentary analysis (Miles & Huberman 1994, p. 9). In stead of statistical processing of numbers (figures or numerically encoded data), qualitative methods rely on categorising data, making connections between categories, and developing conceptual frameworks based on categorising and connection-making (Dey, 1993).

In terms of data analysis, the main difference between a quantitative and a qualitative approach is that there is a need in the former to wait until a sufficient sample size is reached (for example number of returned and exploitable questionnaires) before analysis can begin. Thus, data collection and data analysis are distinct processes (Easterby-Smith et al, 1991). Conversely, in qualitative research data gathering and data analyses are interactive processes taking place simultaneously (Easterby-Smith et al, 1991). In order to proceed in the research and develop new more detailed sub questions with respect to overall research questions, data must be analysed immediately.

Finally, it is important to note that none of the approaches - quantitative or qualitative – are superior or inferior to one another. They are both systematic and scientific, and in particular, they can be complementary (Easterby-Smith et al, 1991; King et al., 1994).

Relating the above discussion to the present research, qualitative questions directed to suppliers would call for the use of a questionnaire, as the suppliers are numerous (450). Questions directed to the auto OEM would call for in-depth interviews with key informants, and qualitative questionnaires in order to reach a larger population within the company.

3.4 Relation to Theory

Strauss & Corbin (1990) define theory as a set of explanatory concepts, based on conceptual labels put on discrete happenings, events and phenomena. As Bergadaa & Nyeck (1992) propose, there can be two main approaches to managing the link between a research project and theory: the inductive approach and the deductive approach. The inductive approach develops new theory from data, while the deductive approach develops hypotheses from existing theory and then test them with research data in order to modify or extend the existing theory (Pras & Tarondeau, 1979).

In the case of this research project, the existing theory in the area of specifications and contracts is very weak and has received little attention in research, thus calling for an inductive approach with concept development from collected data. It is important to note that theory is present also in the beginning of an inductive mode of research (Silverman, 1993), for example, through the researcher's knowledge about existing research that guide the definition of the overall research area in the first place. The theoretical review in the field of specifications suggested the need for further development, as the current research was insufficient. Contracts were not examined with the angle of validating specifications. In this sense, the existing theories helped to formulate the initial questions, and to guide the data collection.

3.5 Unit of Analysis and Perspective

The unit of analysis is a very critical component in the development of the research methodology. This is also stressed by Yin (1989) who comments on the need in case studies to define "what is the case." The unit of analysis is the **specification taking shape in the interchange between an OEM and multiple suppliers**. This includes the establishment of a contract at the start of the relationship and the evolution of the contract during the business relationship in order to validate the specifications.

Karlson (1994) suggests the importance of the perspective from which the research is done, as perspective is a central methodological issue. Danielsson (1983) suggests two complementary main perspectives when studying an organisation, namely from the inside or from the outside. In order to study the problems faced by an organisation, an outside perspective has to be adopted as comparisons can be made with competitors, etc. (Karlson, 1994). In case these problems are inherent within an organisation, an insider perspective needs to be used. In this research, the perspective that has been adopted is both insider and outsider perspective when dealing with the OEM's and an outsider perspective when dealing with the suppliers. Regardless of the perspective, the unit of analysis is the specification used in the interchange between an OEM and multiple suppliers.

3.6 Research Strategies

Yin (1989) identifies five different research strategies: experiment, survey, archival analysis, history, and case study. He argues that all can be used for the different research objectives identified above - to explore, to describe or to explain. For example, there might be exploratory case studies, descriptive case studies, or explanatory case studies. He argues that the choice of research strategy depends on three other conditions: the type of research question asked; the extent of control that an investigator has over actual behavioural events; and the degree of focus on contemporary as opposed to historical events. This research adopts a case study approach for these three reasons. First, the research questions are of 'how' and exploratory "what" kind. A broad array of phenomena must be studied calling for small samples to be analysed in depth (Miles & Huberman, 1994, p. 29). Second, the extent of control is weak in the present research, mainly because of the limited contribution from existing literature and the exploratory art of the research questions. In this situation, the case studies allow for apprehending phenomena and proceed to conceptualisation (Miles & Huberman, 1994, p. 29).

The question of single vs. multiple case studies is delicate (Miles & Huberman, 1994, p. 29). Case study approaches normally starts with one case study, that becomes the "main", "initial" or "dominating" case (Herriott & Firestone, 1983; Miles & Huberman, 1994; Yin, 1989). The use of multiple case studies can lead to more robust and compelling results, by adding confidence – precision and validity - to findings (Miles & Huberman, 1994, p. 29; Yin, 1989). Miles & Huberman (1994) argue that confidence within a single case study can be improved by distinguishing sub-cases within the single case. In the present research this was done by including the suppliers to the auto OEM (both through questionnaires and in-depth interviews), and by researching at multiple levels of the organization (i.e., top management, functional management, project management, and operations). Moreover, data on contracts from one aircraft OEM were included in order to benchmark the main case findings with data from another company in a similar operational context.

The trigger of the choice of the aircraft OEM was that it was exploring some opportunities of collaboration with the auto OEM. Further investigation of the company revealed there were a number of issues that made it interesting enough to be used for comparison interviews. The aircraft is a complex item as it has millions of parts that have to work in unison and also the degree of complexity is more in the aircraft industry than in the automotive industry. There is a high degree of outsourcing in the aircraft OEM. The suppliers in both the firms are involved in varying degrees at various time phases in the development process. This makes it interesting to do a cross-organisational study in the case of contracts. The specifications could also have been dealt with in a cross-organisational manner, but since access to data was a problem, other means like involving the suppliers through in-depth interviews and questionnaires were utilised.

3.7 Choice of Case Companies and Suppliers

Four companies were visited at first, namely car1, truck1, auto OEM and White1, with the aim of getting financing and access to case study data. Also three research foundations were approached, out of which one foundation approved limited funding. The meeting at car1 was not a success, as the proposal could not be presented to the final committee who was supposed to make the decision. Truck1 could not make any decision on the matter and White1 did not want to change their existing relationships with their suppliers. Auto OEM was willing to participate in the project.

The project at auto OEM was initiated after discussions with the Chief Engineer[48] and the Technical Director. Auto OEM was recently acquired by another automotive manufacturer (Mega) and was indirectly a good choice as they were being forced to adopt certain policies of Mega. Mega is one of the world's leading auto-makers and has far reaching global policies that have consequences for all the other auto-makers. The other interesting fact about Mega is its far-reaching low price selection criteria for suppliers, something, which has been imposed on the auto OEM. This had impacts for buyer-supplier relations as suppliers quoted very low prices during the tendering process in order to get the business and later increased their prices for every change made by the auto OEM. This meant that both Mega and auto OEM were required to have very well developed specifications in order to use low price selection criteria for suppliers. Some of the reasons for choosing auto OEM can be listed as follows:

- Multinational company reflecting the globalisation trend in the auto industry
- A wide range of suppliers with varying capabilities

[48] The Chief Engineer not only sponsored this project but also championed it throughout the organisation, thereby facilitating the data collection process.

- Problems with specifications, explicitly mentioned by executives in early phase open interviews
- Problems with contracts, explicitly mentioned by executives in early phase open interviews

It was useful to study the multinational company as certain practices were imposed by the parent company. With direct implication for the present research, the product development process was imposed. It was interesting to understand how auto OEM adapts the new processes to its environment. For example, the imposition of low price selection criteria meant that the purchasing department was cost focused and selected incompetent suppliers who quoted low, while the engineers who were to work with the suppliers had problems due to the in-competence of the suppliers. The auto OEM had problems both with specifications and contracts. The specification problems resulted in the auto OEM not getting the planned products in terms of quality and functionality. Furthermore, the auto industry (to which the auto OEM belongs) can be observed to be one of the largest private sectors in many countries. The mere size allows the auto industry to affect the overall competitiveness of countries such as by impacts on the balance of trade etc.

The aim of this project is to develop an analytical model for analysing the relationship between the buyer and the supplier through the dimensions of specifications and contracts. Identification of as many critical factors/issues as possible is important in this explorative study. The auto OEM makes a complex and advanced product and is a member of a global family of automakers. The car is a complex product that involves numerous components and production steps. There are thousands of components that need to work together and therefore, success depends on the interaction between the hundreds of engineers, purchasers, marketers' etc., working on the project. Furthermore, if components were to be outsourced, then success would also depend on the interaction between the OEM staff and the suppliers. The need for interaction between the suppliers and the OEM becomes all the more pertinent in outsourced product development, given the fact that consumers evaluate the cars in highly subjective ways. Consumer needs are volatile and thus the patterns of development for the car are different from development patterns of products whose performance can be represented to a large extent by objective criteria. The auto

OEM is rich in data, which makes it all the more interesting and can help to identify as many important factors as possible. All the reasons mentioned above allow for the auto OEM to be a reasonable choice for the study.

There were a number of criteria behind the selection of the case study suppliers. This is because all the cases will then meet some criterion useful for attaining quality of research, which is also called a criterion sample strategy by Miles & Huberman (1994). Multiple case sampling was chosen in order to improve the reliability of the findings as, according to Miles & Huberman (1994, p. 29), "by looking at a range of similar and contrasting cases, we can understand a single case finding, grounding it by specifying how and where and, if possible, why it carries on as it does". The cases are representative of a specific group of companies in which a research interest has been identified through a review of existing theory. The supplier companies were chosen by the following guidelines:

- Global operations
- Own research and development facilities
- Partners in integrated development with the OEM firm
- Supplied modules or systems and not components
- Did advanced R&D and have come up with at least one functionality that auto OEM has implemented.

The aircraft OEM's managing director had initiated a meeting on collaboration with the auto OEM in certain key areas of the development and manufacturing process. Some of the reasons that were jointly of interest between the auto and aircraft OEM's include the fact that auto OEM had many different contracts whereas the aircraft OEM had just one contract. This was in spite of the fact that the companies engaged in outsourced development of complex products. Further, there was a need to understand and document the similarities and differences in the processes of both the companies if collaboration in certain areas were to be realised.

3.8 Data Collection

Two sources of data, primary and secondary, were used in this research. The primary sources were interviews and participant observation, while the secondary were archival documentary evidence, informal conversations, magazines, newspaper articles, and attendance at meetings. The author worked as an assistant project leader in auto OEM and had participated in many different projects. This proved to be very beneficial in data collection. The author was involved in many discussions with not only line managers and project managers but also with the top management team.

3.8.1 Interviews

In the fieldwork, interviews were used the most. In the beginning, exploratory interviews (pilot studies) were conducted with twenty-six people located at both the auto OEM and two suppliers. This was done so as to ensure that the research problem was relevant to the auto industry. The interviews offered a unique opportunity of getting the different views of interviewees, which would not have been possible had questionnaires been used. Also, it gave a deeper understanding of how an automobile is developed and produced.

While the exploratory interviews conducted in the pilot phase of the research project were open-ended, the interviews conducted in the case studies were semi structured around the critical issues identified through the pilot studies and the literature study (Appendix 3). Semi-structured interviews were preferred over structured interviews as the latter technique implies a risk of missing important data. Semi-structured interviews are also the best way to detect whether interviewees mis-interpret questions, and they also allow follow up questions to be asked in order to clarify matters. Silverman (1993) confirms the view that semi-structured interviews with open-ended questions are most appropriate when opinions and meanings of the interviewees are sought after, i.e., an authentic understanding of people's experiences is sought.

The people interviewed at the auto OEM and the aircraft OEM ranged from top management to functional management, engineers and technicians in product and process engineering (Refer to Table 3-3). The suppliers were interviewed separately with no presence of the auto OEM staff[49] so as to ensure confidentiality of information. No recording devices were used in order to avoid the structured thinking of individuals. The interviews were conducted both with single individuals and with more than one individual sitting together. The respondents were interviewed at various locations such as the factories, corporate offices, and leisure settings. There were a number of informal discussions outside the workplace.

Both the interviewee and the author directed the interviews. Sometimes the interviewees suggested very critical areas which otherwise could have been missed. The interviewees were first selected by the sponsor of the project namely, the Chief Engineer. After areas became more defined, and by practical experience of working with different people within the organisation the interviewees were selected based on their importance to the research process.

There were some negative aspects of interviewing as well. At certain points in time there was a feeling of losing the focus of the interview, i.e., some questions drifted away from the focus. Some questions asked were sometimes beyond the understanding of the interviewees. Some suppliers were not willing to make statements against the auto OEM for fear of losing business leading to further problems. Most of these problems were overcome by rephrasing the questions, referring back to the questions asked and relating issues to each other throughout the interview process. The interviewees were asked more details around the questions that they were not able or hesitated to answer.

[49] The suppliers were not aware of the fact that the author was a full time employee at auto OEM.

3.8.2 Rough sketches[50]

The interviewees often drew sketches to prove a point[51]. These sketches were helpful to understand their verbal communications better, as they complemented it. Sometimes during the sketching, certain additional details were commented on, which were very relevant for the semi-structuring of the interviews. For example, there were several sketches of the organisation, specification details, etc.

3.8.3 Organisation of the empirical research

The research is focused on two main questions, namely the role of specifications and the role of contracts in outsourced development between the OEM and its suppliers in the automotive industry. The organisation of the empirical research can be explained with reference to Figure 3-1. After a full literature search, two research questions were identified, namely the role of specifications in integrated development between the OEM and the suppliers and the role of written contracts in assisting the validation of specifications in the development process. Yin (1989) comments that pilot studies are not only a pretest, but they help the investigator to "develop a relevant line of questions". The pilot study output was further analysed with the help of the literature leading to a refined interview topic guide for the semi structured interviews in the case study that was conducted in the auto OEM along with detailed interviews at five suppliers. During the case study, questionnaires were distributed to 400 internal employees of auto OEM and 450 global suppliers engaged with the auto OEM. The output of the case study along with the input from the questionnaires resulted in further data analysis and a refined guide for the supplementary interviews that was conducted at the aircraft OEM. All emerging issues as a result of the case study and the questionnaires were dealt with by going back to the auto OEM and the five suppliers. This was done through internal presentations at the auto OEM, the suppliers and joint presentations to both the suppliers and the OEM. The preliminary results of this study resulted in further data analysis and a refined guide for the

[50] All the figures / models that arise as a result of the analysis were derived after the all the case studies were completed. In many cases, rough ideas of models /figures were created but never signed off until all the interviews were completed.

[51] Sketches are illustrations that were drawn on the black board. For example, when the author did not understand the different parts that an air condition system was composed of, one of the engineers drew a sketch of the air condition system on the black board.

supplementary interviews that were conducted at the aircraft OEM. All emerging issues with regards to contracts were referred back to the auto OEM. The result of the analysis of the case study and supplementary interviews at the aircraft OEM resulted in the final data analysis resulting in the complete thesis report.

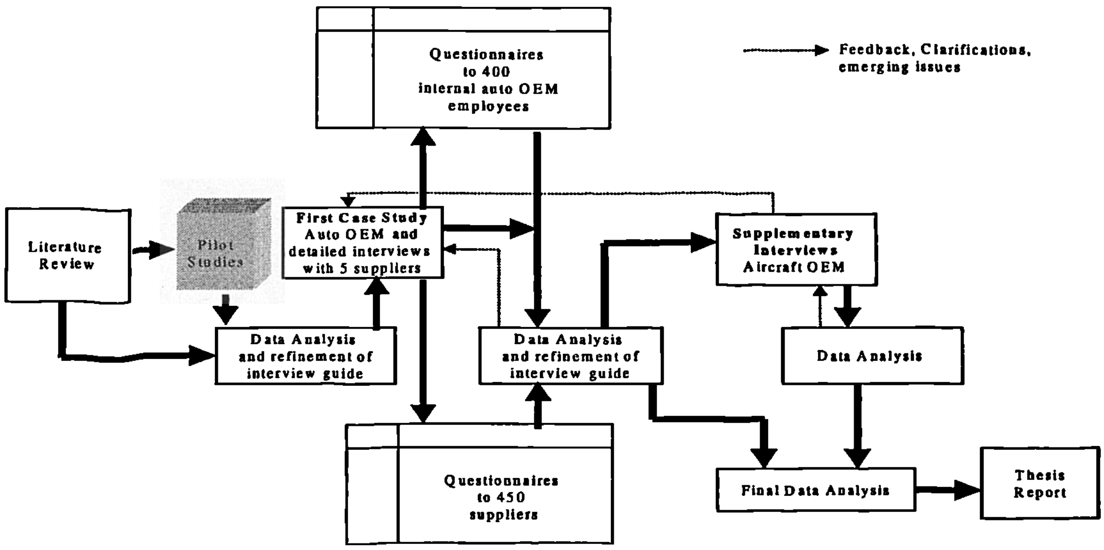

Figure 3-1, The organisation of the empirical research

3.8.4 Documentation

A wide variety of documentation was made available such as vehicle technical specifications, system technical specifications and the component technical specifications. Organisation charts, project management internal documents, product development process charts, prototyping charts, timing charts, budget details, etc., were among the many documents that were made available. A copy of "auto OEM Today - internal magazine" was useful in learning a bit of the company culture. Please refer to Appendix 1 for further details on the documents used.

3.8.5 Participant Observation

A great deal of information was obtained by observation. Observations included the way the auto OEM personnel dealt with their suppliers, their attitude towards them etc. It was observed that both the auto OEM employees and the suppliers did not have any personal relations with each other, for example, evening socialisation. The whole question of better integration centres on better communication. In the same context it was noticed that some of the suppliers did not like some of the auto OEM staff and vice versa. This could lead to breakdown in communication, for example, according to one supplier, an auto OEM employee with more than five years tenure was a burden as he became stale in the saddle and was reluctant to accept new ideas.

Since, the author worked in auto OEM as a full time staff, there were opportunities to understand clues that are an important part of communication (Czarniawska-Joerges, 1992) and also to record actions. The author was an active participant, however, care was taken to separate the comments of the people working in the company, as opposed to the authors comments during the many different meetings by explicitly making it clear in the field notes.

There were a number of advantages of working in auto OEM. It allowed the author access to the way the auto OEM functioned internally which is generally hidden from the outside world. For example, the emotions and stresses that are displayed during the development work. This also allowed the author to experience situations which researchers would otherwise have been deprived of (Sofer, 1961). Participant observation allowed the author to record actions and consequences with the help of first hand knowledge, instead of relying on others at auto OEM to describe the situation. Being employed at auto OEM meant that the author had to take an active role rather than a passive role, the latter could have meant exclusion from certain fields at the auto OEM. According to Sandy (1979), the active researcher gathers data and observes by using himself as the mode of observation. This allows collection of immense impressions that could later help in the analysis and interpretation process. In order to separate the comments of auto OEM staff from the author's personal opinions, care was taken to make sure that the field notes were clearly marked whenever the author voiced opinions.

There were a number of disadvantages of working in auto OEM as well. For example, the author was affected by the "good" intention to help the auto OEM to solve their problems. There was a feeling that the author was becoming more of a consultant than a researcher. Becker (1958) comments on the drawbacks of participant observation and states that the participant observer may not have sufficient time to take notes or raise questions from different perspectives, the observer may have to take positions contrary to the interests of good scientific practices etc. In order to minimise these effects the author undertook a number of steps. The author tried to take notes of most of the discussions and record them over a Dictaphone during the first available moment. Every evening from 18.00 hrs to 23.00 hrs the transcripts were written down. Notes were routinely made if possible during the meetings using symbols, flow charts, etc.

While the author did take sides during meetings and discussions, care was taken to record the opinions of the other side so that the reflections and analysis were made with an open mind. During the heat of discussions, it is difficult to judge as to the correct side and hence noting comments from both the sides can help to reflect rationally after the meeting or the first available free instant. The habit of becoming a consultant rather than a researcher was a drawback. The author had to read and re-read the analysis in order to avoid possible suggestions to auto OEM. Speaking at seminars for other firms, asking co-researchers to read the transcripts, etc., helped to minimise the "consultant" effects. Another step that the author took was to follow the advice of Schön (1983b) and be aware of the effect that the author had on the others at auto OEM. As a participant observer, it was important to note the actions taken by the author and their reception by others in the auto OEM. By being employed in auto OEM, there was an opportunity to assess the effects of intervention by the author and discuss perceptions with colleagues. Czarniawska-Joerges (1992) suggests that such an awareness is "the best remedy against self confirming hypotheses and irresponsible interventions". Finally, it would be appropriate to say that all attempts were made to minimise the side effects of being an active participant observer.

3.8.6 Questionnaires[52] to suppliers

Questionnaires[53] were used to gather the opinions of the suppliers to auto OEM. Since it was not possible to interview 450 suppliers located across the world, questionnaires with qualitative questions were sent to the suppliers. These supplemented the data gathered from the OEM firms, so that the research did not turn out to be a one-sided story. The questionnaire asked the supplier to comment (with reference to auto OEM) on the meaning of specifications[54] and the problems faced in the specifications[55]. I will take an example to show how the questionnaire study was dealt with. The question that was asked was an open-ended one, namely **"What does the term specification mean to you when considering the activity/function that it is expected to execute?"**[56] Similar answers to the questionnaires were grouped together. For example, some of the answers were as follows:

- Requirements that the product has to fulfil for the OEM.
- Requirements that the product has to fulfil for the customer.
- OEM wants us to do something and we do it.
- We need to satisfy the product requirements requested by the buyer.

The above answers were regrouped together under the statement "Requirements of the user/customer that the product has to fulfil". For every statement, a certain percentage of supplier responses are counted. It is to be noted that many suppliers have more than one meaning for the term specification and hence, many suppliers have more than one response.

The questionnaires were developed and posted to the suppliers after important input from the first in-depth case studies was obtained.

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[52] A copy of the questionnaire is presented in appendix 3.

[53] The questionnaire was directed to the project groups at the suppliers that were dealing with the auto OEM. The head of the group or the chief project leader was requested to fill in the questionnaire with the dominating opinion of the project group. The questionnaires were not directed to several individuals at one supplier firm as the OEM sees the suppliers as single entities and not as a collection of x number of individuals. Furthermore, the aim was to gather a broader range of answers from as many suppliers as possible.

[54] This question was answered by 243 suppliers, indicating a response rate of 54%

[55] This question was answered by 350 suppliers, indicating a response rate of 77%

[56] See appendix 5 for a detailed overview of the manual factor analysis

3.9 Company Data Verification

The data verification was a very important task. All interviews were typed and printed at the first available opportunity. The interview transcripts were then sent to the various actors (both the interviewees and the mentor for this project) for verification, however confidential details were marked out. The mentor of this project, namely the chief engineer, received a copy of the interviews for factual verification. As far as possible, the last ten minutes of every interview were used to cross check the contents of the interview conducted. This also provided an opportunity to clear any doubts. Discussion papers were regularly presented at internal seminars[57] for different levels in the organisation. This proved to be very valuable as comments were instantaneous and there was a very lively discussion. Several themes were explored and the discussion papers were thus made complete. Access to the company staff was more or less guaranteed, as the project was company sponsored. All the interviews were conducted in English, though with certain staff the interviews were conducted in a mixture of both English and the local language.

3.10 Data Analysis

The open coding technique of Strauss & Corbin (1990) was utilised in order to analyse the field notes from the semi-structured interviews and observations. The open coding technique is described as follows:

- **Labelling events**

Data was broken down by giving each incident, idea or event a name to represent the phenomenon. Similar events were given the same name.

- **Categorising**

After the field notes had been typed, they were ready for analysis. Coding is analysis, according to Miles and Huberman (1994), who also state that analysis is to dissect the

[57] The author also presented the material at the supply chain conference in Göteborg (Sweden, 1997), IMIT summer seminar (Stockholm, 1998) etc.

field notes meaningfully while keeping the relations between the parts intact. Codes are tags or labels in order to assign units of meaning to the information contained in the field notes. Codes could be either straightforward or metaphors. Each separate incident, idea or event was assigned a code and similar events, ideas, or incidents had the same code.

A large number of codes were generated as a result of the coding (approximately 60 codes were generated). Codes that pertained to the same phenomenon were regrouped and given a separate code. The regrouped codes or categories were necessary in order to identify themes, patterns, differences, similarities, etc. This can be achieved by checking each code with the others to find categories. One can have many sub-categories within a particular category. The categories and sub categories was done through an analysis of the patterns in data (interviews and questionnaires – chapters 4, 5 and 6) and this process was also guided by the research questions. Coding is time consuming and an important part of the research process. It took 4 weeks of full time work to code the data. I will demonstrate the coding with the help of an example. One of the categories identified was validation. This had a number of sub-categories like end product validation, validation at the suppliers, validation for entry, and validation for doing business. This contained all the criteria connected to validation. Now the dimensions of the sub categories need to be looked into, i.e., by looking into problems, problems and causes or problems, causes and possible remedial action. Validation criteria for entry can be dimensionalised by asking why are suppliers selected? What are the criteria to look into while selecting suppliers, etc. The dimensionalisation helps to model and conceptualise the way in which validation functions, compare different settings and relate categories and sub categories to each other thus creating a better understanding of the phenomenon.

3.11 Validity and Reliability

Denzin (1978) and Patton (1987) define triangulation as the combination of methodologies to study the same phenomenon which according to Grant (1997), is necessary in order to avoid interviewer and respondent biases, clarify detail and cross check responses. The adaptation of triangulation in qualitative methods has been in the use of multiple methods to study a single problem. Different viewpoints make the interpretation more valid and reasonable, increase the reliability of the data (Kaulio & Karlsson, 1997) and thus provide stronger substantiation of constructs and hypotheses, as pointed out by Eisenhardt (1989). Multiple interviews and informal conversations can bring different perspectives on the same problem and archival documentary evidence can be used to extract data from an impartial, "dead" source (Grant, 1997). The researcher's experience with specifications and contracts proved invaluable for collecting observational data from the case companies. The following Table 3-3 summarises the triangulation used throughout the cases.

Date	Method	Company	Interviewees	Data collection method
Sept,96-Nov96	Single site, in depth exploratory study	Car Manufacturer, Cooling systems supplier, Wire Harness supplier **26 Interviews**	Vice presidents, Project managers, project leaders, Object leaders, Chief engineers, Line managers, Staff functions	Semi-structured interviews, Observation, Attendance at meetings, Informal conversations, Archival, Questionnaires **(Pilot study)**[58]
Nov 96-Sept 99	Single site, in depth exploratory study[59]	Car manufacturer **250 interviews**	President, Vice presidents, Project managers, project leaders, Object leaders, Chief engineers, Line managers, Staff functions, Purchasers, Production staff, Human resources, Brand manager, Marketing managers, Legal managers, After sales staff	Semi-structured interviews, Observation, Questionnaires[60], Attendance at meetings, Informal conversations, **(Case study)**
Sept 98 Nov 99	Single site, in depth exploratory study	Aircraft OEM **15 interviews**	Development director, Vice presidents, Purchasing director, Quality Director, Quality manager	Semi-structured interviews, Observation, Attendance at meetings, Informal conversations, Archival, Questionnaires, Physical artefacts **(Supplementary Interviews)**
Sept 97-March 99	Single site, in depth exploratory study	Assembly Process Supplier World wide operations **14 interviews**	Line managers, General manager, Project manager	Semi-structured interviews, Informal conversations, Archival, Questionnaires, Physical artefacts **(In-depth Interviews)**
Nov 96 - Oct 99	Single site, in depth exploratory study	Wire Harness Supplier, World wide operations **32 interviews**	Project manager, project staff, Business manager	Semi-structured interviews, Observation, Attendance at meetings, Informal conversations, Archival, Questionnaires, Physical artefacts **(In-depth Interviews)**
Jan 97 – April 99	Single site, in depth exploratory study	Seating supplier **25 interviews** Worlds leading supplier of seats	Engineering director, Project staff	Semi-structured interviews, Observation, Attendance at meetings, Informal conversations, Archival, Questionnaires, Physical artefacts **(In-depth Interviews)**
Oct –97 - Dec 97	Single site, in depth exploratory study	Cooling system supplier **3 interviews**	Business unit manager	Semi-structured interviews, Observation, Archival, Questionnaires, Physical artefacts **(In-depth Interviews)**
March 97 - July 97	Single site, in depth exploratory study	Electronics supplier **6 interviews**	Resident engineer, Project manager	Semi-structured interviews, Observation, Informal conversations, Archival, Questionnaires, Physical artefacts **(In-depth Interviews)**

Table 3-3, Description of methods used, data sources and time spent[61]

[58] There were three pilot studies in total namely, one at the auto OEM and one each at the cooling systems supplier and the wire harness supplier. These two suppliers were chosen because they had given access to the author for interviews. These two suppliers were also chosen along with the remaining three suppliers for in-depth interviews following the guidelines laid down at the beginning for supplier selection.

[59] The author was employed at auto OEM. This proved to be helpful in understanding tacit knowledge possessed by the employees.

[60] 450 questionnaires were distributed to the suppliers after important input was gathered from the case study. Further, 400 questionnaires were distributed internally within auto OEM (after the case study) in order to observe whether the visions that guided their development work encompassed visions for suppliers as well.

[61] Names of the companies are confidential and cannot be revealed.

There are four tests which establish the quality of empirical research, namely construct validity, internal validity, external validity and reliability (Yin, 1989). Reliability ensures that if a future researcher follows the procedures of this study then the same results are evident. Hence there is a need for documentation. To increase the reliability of this thesis, all references are clearly quoted, the case study questions clearly specified, and the background behind the research mentioned. Typing field notes directly after the interviews and observations increased reliability. Coding of the data was done as soon as possible to begin preliminary analysis and also serve as a basis for the forthcoming interviews.

Construct validity is to ensure that subjective judgements are not made when collecting data. To ensure this, a chain of data collection methods was used, such as interviews, direct observations, participant observation, documentation, etc. Typed transcripts were also made available to different managers in the firms for ratification. In the present research, care was taken to follow the suggestions of Silverman (1993) which state that validation is possible only if the results of the analysis are compatible with the self-image of the respondents. Original field notes were preserved and possible biases were counterchecked with them. In some cases, when contradictory answers were obtained, the original interviewees were questioned again and it was observed that the questions asked were themselves of a contradictory nature. There was very little divergence between the original field notes and the informant's reviews.

Internal validity is used for causal and explanatory studies only (Yin, 1989) and hence is not applicable in this case. The logic behind this is to find the relation between variables and find out what caused what. In a case study, it is very hard to point out the relationships, as some relationships are not visible and hence may be difficult to pin point.

External validity is to test whether the results of a study can be generalised. Yin (1989) comments that case studies are concerned with analytical generalisations as opposed to statistical generalisations used in surveys. Analytical generalisations are all about developing new theory (Strauss & Corbin, 1990) or relating case findings to existing or emerging theories in order to extend existing theories. According to Yin

(1989), if two or more cases support the same theory, then replication may be claimed. The research questions in the present project are to generalise the findings to the theoretical discussion on specifications and contracts, as discussed in chapter two, and to other literature pertaining to emerging concepts.

3.12 Conclusion

First the research questions were identified. The research questions were specified and finally formulated after a full literature search and were influenced by previous experience and personal interests of the author. The questions are exploratory in nature and are of the "what" kind and the "how" and "why" kind to some extent. The objective of the study was to understand the role of specifications and contracts.

The unit of analysis was identified to be the specification taking shape in the interchange between an OEM and multiple suppliers. This includes the establishment of a contract at the start of the relationship and the evolution of the contract during the business relationship in order to validate the specifications.

Due to the fact that the specification has received little attention from researchers (weak body of existing literature), an inductive approach was justified. The research strategy identified the use of case studies in order to get a deeper understanding.

After the literature search was completed, two research questions related to the roles of specifications and contracts in outsourced product development were identified. These two research questions were used in the pilot interviews, which allowed for a refinement of the questions to be used in the case study.

Data analysis was tuned to the advice proposed by Strauss & Corbin (1990). The field notes were first typed at the first available opportunity. Categories were developed by labelling events and grouping similar events together. Reliability and validity issues were taken care of by following the strategies proposed by Yin (1989).

4. DATA ON THE SPECIFICATION PROCESS AND CONTRACTS

4.1 Introduction

This chapter[62] describes the specification process in the auto OEM, different functions involved in the specification process in auto OEM and the contractual process in both the auto and aircraft OEMs. The data on the "written document called the specification" is presented in the next chapter. This is to facilitate analysis and thus allow the reader to understand the sequence in which the analysis is done. This chapter serves a very important role of introducing the reader to the data collected in the firms. This is a data collection chapter and data is presented in a raw form. There will be no analysis of the raw data in any form in this chapter. The data presented in this chapter and the next chapter (5) is also indicated in the Figure 4-1 below.

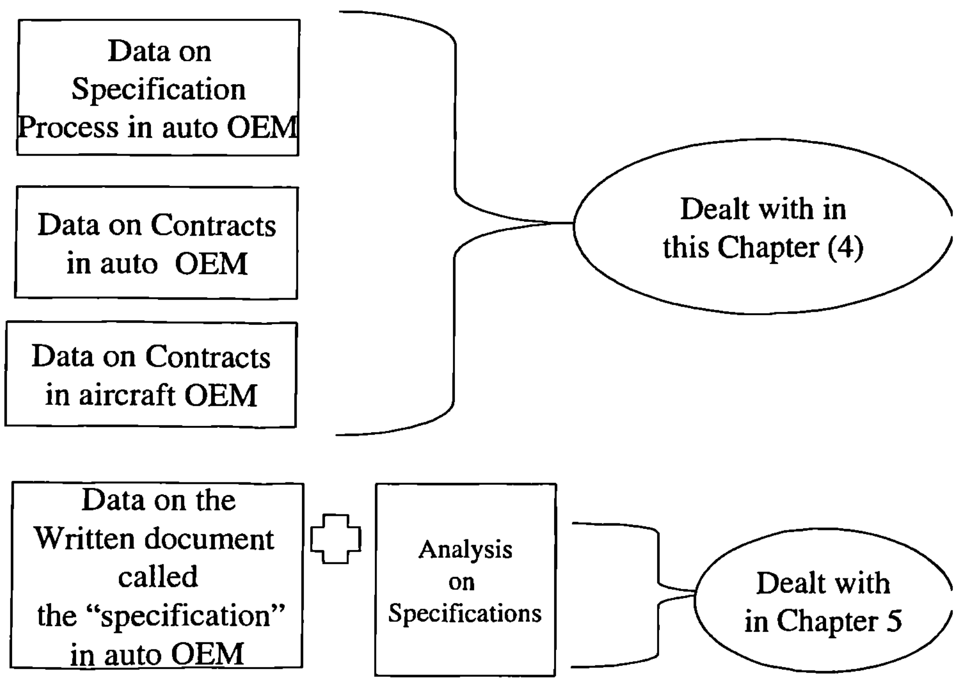

Figure 4-1, Data Organisation

[62] The data for this chapter has been collected by examination of documents, interviews, and personal observations

4.2 The Specification Process in the Auto OEM

Both the auto OEM and its suppliers have different opinions as to the significance of the specification. The auto OEM has different levels of specifications. The marketing department generates the market segment specifications (MSS) which are the starting point for further development of the specifications. It consists of market trends, own brand requirements, voice of the customer, competitor analysis, supplier input and the voice of the distributor. The market segment specification, along with the brand requirements, then generate subsequently:

- The initial vehicle technical specifications (IVTS), which is a preliminary specification regarding the architecture of the car,
- The vehicle technical specifications (VTS), which is the specification for the whole car,
- The sub system technical specifications (SSTS), which is the sub system level specification, and
- The component technical specifications (CTS), which is the component level specification.

Figure 4-2 illustrates the links between all these different specifications.

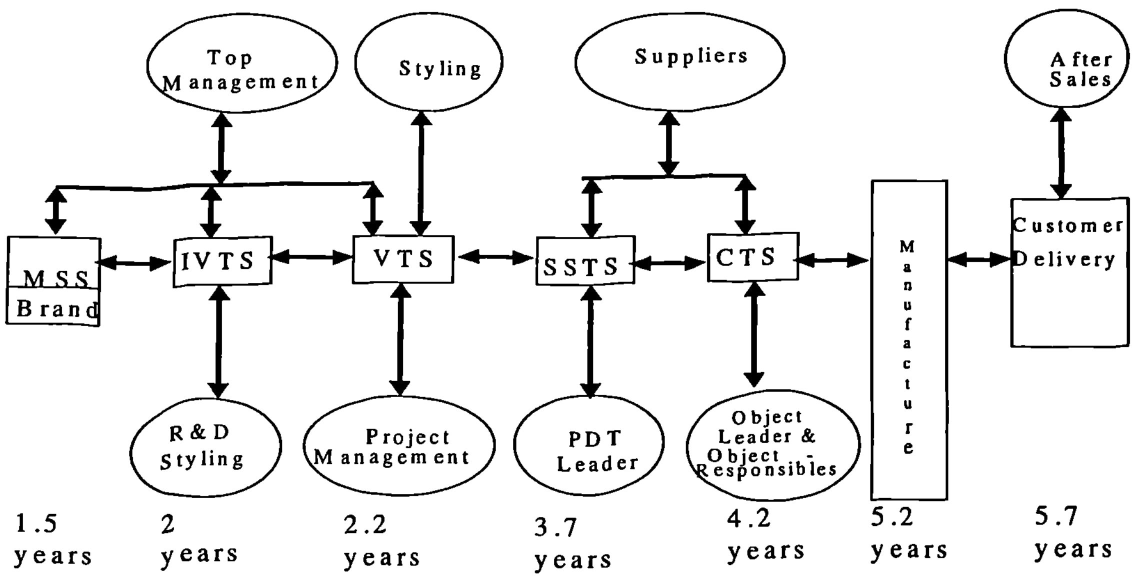

Figure 4-2, The specification process at auto OEM

- The market segment specification (MSS) is the point of departure for the entire specification process. It directly generates the initial vehicle technical specifications (IVTS) with input from R&D and styling, and continuous input from top management.[63]
- The vehicle technical specification (VTS) is generated from the IVTS. Here, project groups are formed and start to play an important role in the development process. Top management and styling still provide important input at this stage.
- The sub-system technical specification (SSTS) is generated from the VTS. These specifications are managed at the product development team leader (PDT) level. Suppliers are also invited to work on this level of specifications.
- Finally, the component technical specification (CTS) is generated from the SSTS. Object leaders and staff intervene here as well as suppliers.

The time periods for the various stages are depicted in the Figure 4-2. It generally takes auto OEM about 5.7 years before the car is in the hands of the customer. Again, it must be noticed that the time periods are for a completely new platform or a car that is built according to a new architecture. In a case where there are only small changes in the car model, the entire process may take around 2 years. The generation of the MSS takes around 1.5 years and could be more or less depending upon whether any pre-concept market studies have been engaged in. It may be observed that the generation of the IVTS takes about 0.5 years. This is because the IVTS is worked in parallel to the work done on the MSS.

There are different functions and management levels involved in the specification process. Project members work in a matrix organisation with the line management.

In the auto OEM, the entire car has been split up into six systems, namely electronics, electrical, chassis, body, engine, and climate. This happens in the transition between the VTS and the SSTS. The systems are made up of objects, which in turn, are made up of components. Figure 4-3 depicts the breakdown of the VTS into the sub-systems and objects.

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[63] Refer to appendix 2 for further details on the organisational structure

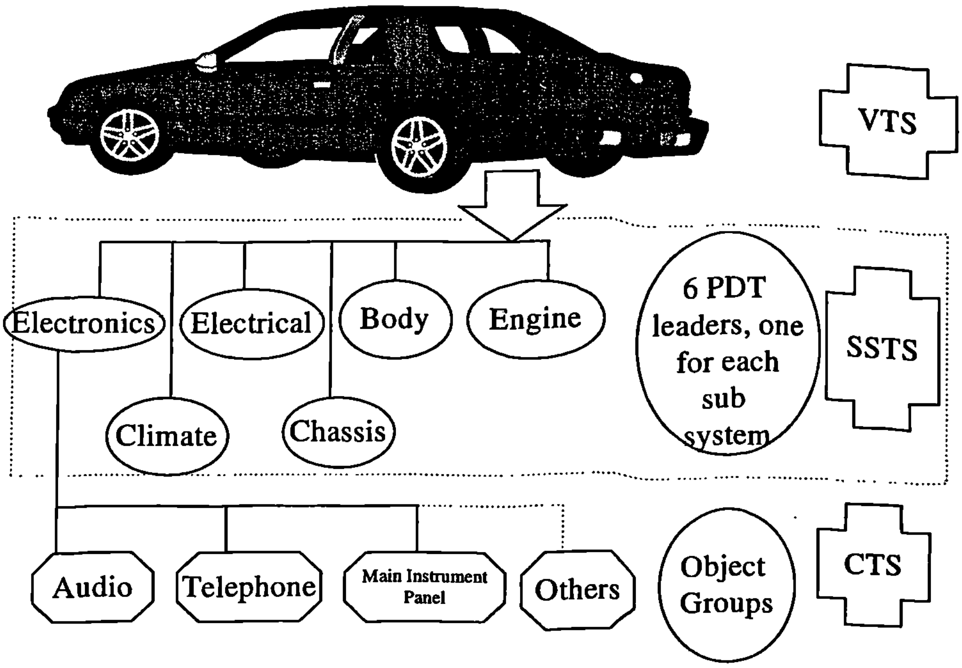

Figure 4-3, The breakdown of specifications[64]

The SSTS is generally the domain of the OEM, but in certain cases the SSTS can be generated jointly by the OEM and the supplier. The CTS is made by the supplier but is subject to frequent interference by the OEM. Validation plans (both by the buyer and the supplier) are made at the VTS, SSTS and the CTS level. Once the specifications have been iterated and simulated, they are sent for manufacturing. In case of problems, the specifications are revisited. After manufacturing, the customer deliveries are made and the customers then deal with the after sales staff for requirements on spare parts, etc. I will now describe the different departments involved in the specification process and the intervening conditions in the specification process.

4.2.1 Role of Top management in the Specification Process

Top management consists of the President and all the Vice Presidents of the OEM. These people are instrumental in defining the brand of the organisation, which is the first step when starting up a specification process. At the beginning of a project, top management asks for information from the marketing and engineering departments and decides the features to incorporate. For example, if the market wants a turbo

[64] The IVTS is not shown in the figure as it could be developed for any future model and may or may not be used in a particular project.

engine and the OEM is the best in turbo engines (they employ a lot of consultants in order to benchmark in price, quality, etc.), then top management may make a decision to incorporate a turbo engine. While the top management is involved in the setting of the total program cost of the car, the individual costs for the objects are decided by the financial department in conjunction with the purchasing department. These costs have to be in line with the total program cost.

4.2.2 Role[65] of Research and Development in the Specification process

This department is instrumental in developing the initial vehicle technical specifications. They also develop the product profile and interact with the marketing department in order to translate the market requirements into technical requirements. Many people in the organisation are not aware that the R&D department generates the initial VTS. The R&D department is instrumental in designing the geometry of the car and is responsible for deciding the various hard points in the car like the distance between the eyes of the driver and the front glass shield of the car, the size of the car, bonnet height, ground clearance, dimensions of the wheels, i.e., all numeric measurements that are passed on to the styling department for further analysis and design work, reduction of noise in the car, reduction of fuel consumption, etc.

The R&D department is divided into the following sections: engine concepts, chassis-drive train concepts, simulation/computation and the platform or vehicle architecture concept. All these different sections propose vehicle characteristics for the different car lines. After the concept is initiated, the R&D representative works with project management and checks whether the car fulfils the characteristics that were originally decided. There is no manufacturing input to the R&D.

It can be observed that concepts are developed for only certain items that are considered strategic by the auto OEM. The non-strategic activities are based on standardised technologies, for example, the brake systems, etc., while the strategic activities are based on non-standardised technologies.

[65] Data was collected by interviewing staff in the different departments.

4.2.3 Role of Styling Department in the Specification process

The responsibility of the styling department is to ensure a good appearance for the car both in the interior (for example, the appearance of the seat, the radio system appearance, etc.) and the exterior (shape of the car etc.), to satisfy the aerodynamic considerations, and to satisfy the human factors in the car, etc. The temperature in the hood depends on the way the hood is styled which highlights the criticalness of the styling department. Styling is more creative work. A bill of styling is created which consists of benchmarking the styling of the car, specifying the brand requirements and vehicle proportions, i.e., where to place the wheels, for example, etc. However, the designers are not free to design as they want, since they have a lot of hard points that are dictated by the R&D and engineering department.

4.2.4 Role of Brand/Marketing Management in the Specification process

The brand management's role is to make the specifications in line with the image of the company. For example, the brand of auto OEM is safety and hence all safety features are emphasised. The rear seat belt warning sign is a safety feature. If this feature is removed during a trade-off decision, then two issues are obvious. Either safety is not the brand of the company, or the brand vision is not clear within the organisation. The brand is important in order to get the price premium and also to be close to the customer. In elaborating the brand strategy, the auto OEM focuses on 5 important dimensions:

- **Product Category:** Which product category is the focus of the OEM. For example is it sports cars, family cars, leisure cars or executive/conservative cars.
- **Needs:** What are the needs in each product category. The needs could be safety, security, high rpm, superior quality, aesthetics, etc.
- **Heritage:** Why are we doing the product the way we do it? For example, Volvo produces cars that have an image of providing extreme safety for the family.
- **Expression:** How do you express yourself to the customer? For example, BMW does not have humans in their advertisements. Humans spell imperfection whereas machines project perfection.

- **User identity:** The user identity needs to be projected. For example, a particular car could be projected for unmarried successful business people, another for DINKS (Double Income, No Kids), a third for young families, etc.

The marketing department provides input from customer demands. However, customer demands are not always interpreted correctly. Brand identification is a part of the marketing department. There are frequent changes in the MSS and especially towards the end of the development process, which according to the marketing department is an outcome of the frequent changes in the customer demands. The marketing department does not always validate whether their demands are being fulfilled or not in the product development process at regular intervals. The marketing department has a shortage of staff and is thus unable to staff all the object groups.

4.2.5 Role of Finance Department in the Specification process

The finance department operates within the core team[66] and at the outset of a project, the program controller is responsible for building up a business case. The finance department is cost focused when dealing with the engineering department as opposed to being revenue focused. The major problems faced by the program controllers concern getting the engineers to specify what they actually want. The product cost, supplier-tooling cost, necessary process changes at the supplier, etc., can be found out once the engineering needs are clearly specified. The program controller then comes up with a cost estimate for all the parts. The finance department has benchmarked data for the parts and thus ratifies their cost estimates. In many cases, the program controller convinces the technical department to make parts at a lower cost (in case the technical department comes with a higher cost estimate). Also, the technical department can convince the program controller otherwise, in which case, some parts of the specification will have to be deleted or changed.

[66] Refer to Appendix 2 for an overview of what the core team means.

The program controller first calculates the price at which the market will accept the product and based on the knowledge of the required cash flow, profit, etc. for long-term survival, calculates the maximum allowable cost and the breakdown of this cost. The most important aspect is to deliver a product at an affordable cost.

4.2.6 Role of Project organisation[67]/Project Manager in the Specification Process

The Project manager has two basic roles, namely to be a leader and to be a program support executive, i.e., having personnel under his or her tutorial giving support to others involved in the product development process. As a support function, the project manager is responsible for implementing the product development process that the company follows. Project management responsibility also involves planning structures, gates (dates where pre-determined attributes are checked and decisions made to either continue or delay the project until completion of the pre-determined activities), quality checks, and so on both internally and externally. For each particular car line, there is one project manager.

Different project managers[68] run projects in different ways. For example, a project manager with a technical background may be more inclined to discuss details than a project manager with a commercial background. Experience, interest in project management, possibilities to grow and personal working styles can differentiate project managers. Certain project managers can be very bossy and interfere in minor details such as the shape of screws, while some can be very broad minded, empower personnel and believe in their ability to perform. Still others are oriented towards a rigorous planning of every single project activity and prefer to manage their work to a large extent from their desk in an analytical, almost scientific way. Some are more "relational-oriented" and practise a "management-by-walking-around" approach.[69]

There is no need for a project manager to have very detailed technical skills, but there is an acute need for making sure that the right people with the right skills are present

[67] The suppliers are present in the project organisation depending upon when they are involved in the specification process.
[68] This research did not include measurements that made it possible to determine if the project managers training and background affected the work being carried out.
[69] Both types of project managers were present in auto OEM

within the project to do the job. In outsourced product development, the role of the project manager extends to ensuring that the right people are present at the suppliers as well. The role of the project manager is not to design the car, but to lead the project to success by managing the competencies of his or her team (including the suppliers) and the constraints of the project.

4.2.7 Role of Project Organisation/PDT leader/Object leader/Object responsible in the Specification process

The PDT leader is in charge of several objects at the same time, while an object leader is in charge of one single object. An object can be defined as a collection of components which are integrated together by a group of dedicated cross-functional people from marketing, purchasing, finance, production and after sales, i.e., the object group and includes the suppliers. For example, the sub-system electronics contains the following objects: radio, telephone, dice/twice, main instrument panel and side instrument panel. The object audio system will contain the radio, amplifiers, loudspeakers, antennas and CD changer. The number of objects will be decided by the resources and time that the auto OEM can afford. There are 6 PDT leaders corresponding to the six sub systems electrical, electronics, chassis, body, engine and climate. The PDT leaders deal with a number of objects in their areas. While the object group does all the technical work, the PDT leaders follow up on quality, timing, cost, and priority of the different jobs. The project manager follows up each and every object in the car. If there is a problem with the radio, the object team will approach the project manager who will then reach a decision on whether or not to accept changes in order to solve the problems, for example, changes in the composition of the radio, its performance, cost or timing. This will, in turn, be conveyed to top management who will decide on streamlining the start of production, for example, carrying on testing of the full prototypes without the radio in case it is not ready.

4.2.8 Role of Manufacturing in the Specification Process

The manufacturing engineers are responsible for the assembly processes while the shop floor assembly staffs are responsible for actually building and obtaining the product. Many times, when the specifications do not meet customer requirements, product engineering makes changes to the specifications in a non-standardised manner, which adds to manpower, scrap, cost, etc. Product engineering is focused on new products and does not seek to solve problems with existing products. Poor quality of the specifications may result in a defective product, as the process may not be suitable to manufacture it, the tooling may not match, etc. When the specifications do not match the tolerance levels on the tools, then defects are manufactured. If the role of manufacturing is downgraded, then the role of production becomes even more downgraded as they will always have to make the compromises.

4.2.9 Role of After Sales/Service in the Specification Process

The after sales/service department go through the design of the entire car and divide it into smaller sections with the intention of making "design for repairability and serviceability". Their requirements need to be included in the specifications. It is their responsibility to ensure that the design of the car allows easy serviceability and repairability. They identify the wear and tear units, so as to have an optimised level of spare parts. For example, if there is a problem with the gearbox, then it should be possible to simply remove it rather than cut out the whole gearbox. The after sales people work together with the different object groups and jointly explore mock-ups and prototypes. The later the after sales staff are involved in the design process, the fewer are the possibilities for change. The following are some examples of the different after sales requirements on the different specifications.

VTS	• The car should run for 30,000 kms without any maintenance. • The car should be able to operate with a particular oil.
SSTS	• There should be easy access for the refrigerant to be used in the air conditioning unit. • The tools carried by the car should be sufficient for operations within the car.
CTS	• There should be standardised bolts so that all the bolts can be fastened or unfastened with the existing tools in the car.

The car is a compromise. I will illustrate this with the help of two examples. Production wanted the door hinges welded to the body while the after sales staff wanted the door to be bolted to the body so that the door would be adjustable. However this would have meant extra staff on the shop floor to adjust the doors while the bolts are being fixed. The second example concerns an opening in the dickey of the car through which the fuel pump could be reached, removed and changed. This feature existed on the older models of auto OEM. However, the stamping operations to ensure the opening cost money. Hence, it was abandoned in the new model. Now the whole fuel tank has to be removed in order to replace the fuel pump. It takes more than an hour to remove and replace the fuel pump as compared to the few minutes when the fuel pump was accessible through the dickey. The above examples indicate that the specifications need to consider the customer requirements of easy accessibility, serviceability and repairability during the making of the car.

4.3 Intervening[70] Conditions

The following factors[71] were identified as affecting the specification process. These factors can be also seen as intervening conditions in the specification process.

4.3.1 Directives

In order to understand directives I will consider the specifications at the CTS level. I will take the example of an object, the radio, in order to facilitate this understanding (an entire system may involve thousands of components and interfaces). The radio object leader issues an object directive from the program management, which contains a description of the expectations from the object. The object directive consists of many elements:

- The risks involved with the object
- A table for the financial side of the business
- Weight expectations
- Development cost
- Date for the start of production
- Supplier investment in tooling
- Material cost in each car

[70] This word is used at auto OEM.
[71] There is no order of importance in which the factors have been written.

- Prototype cost
- Number of hours from the OEM and external consultants

Financial figures are generally for eight years and the costs are expected to decrease during this period by certain rates. Based on the different figures, the total cost for each year can be determined. It is in the interest of the object leader to keep the suppliers within the budgeted costs. However, for any change, the program management has to give approval.

From the object directive, the object leader, together with object responsibles, develop a list of parts that are to be used in the radio, based on their previous experience. These lists of parts are further developed into drawings. The people who develop the drawings and parts vary from object to object. In most cases, the auto OEM staffs deal with the drawings and parts at the component and sub-system level, even though the suppliers are supposed to do this depending on their capabilities. Suppliers are called in very late, e.g., when the parts do not work. The suppliers are then required to make modifications in the original drawings of the auto OEM and to develop new ones, which is tantamount to back loading in the development process.

A new car model is always a compromise. This means that all the non-conformities to the specifications cannot be solved before the customer gets the product - so called running changes.[72] Problem Tracking is a tool used in the compromise decisions by the auto OEM.

[72] No auto is perfect. All autos have defects though some are not noticeable and hence do not end up as customer complaints.

4.3.2 Problem Tracking

The vehicle technical specifications[73], sub-system technical specifications and the component technical specifications are the flow down from the whole car to the components. These specifications have validation plans namely the vehicle validation plan, the sub-system validation plan and the component validation plan. The problems that are found after the validations are completed are classified into three categories:

A These are very serious problems that could lead to customer complaints

B With the existence of these problems, production staff will have difficulties in ensuring the quality of the work. In the case of blind assembly, the operator fitting a part under the car does not know whether the part has been fit correctly or not, as there is no feedback. This can be overcome by the operator hearing a click every time s/he puts the part under the car.

C These problems are minor and hard for the customer to notice. For example, loose clips holding the cables in the car or if the indicator (left or right) misses a tick in the "tick-tack" sequence once every thousand times of use.

It is important to note that the problems may move from one category to another, i.e., an A problem could become a B or C. If an A problem has been solved in engineering, but not validated or corrected, it could become a B or C problem. There is a chart / log book that records all the problems at any given week as shown in Figure 4-4 below. The main aim of the problem tracking is to ensure visibility to the organisation on whether the problems are decreasing. During the course of n weeks, all the A problems need to be solved as these are the most serious of all problems.

[73] The overall vehicle technical specification is always the same within a platform though, the sub system technical specification and the component technical specification are developed to various degrees within a platform depending upon the variants required from a platform.

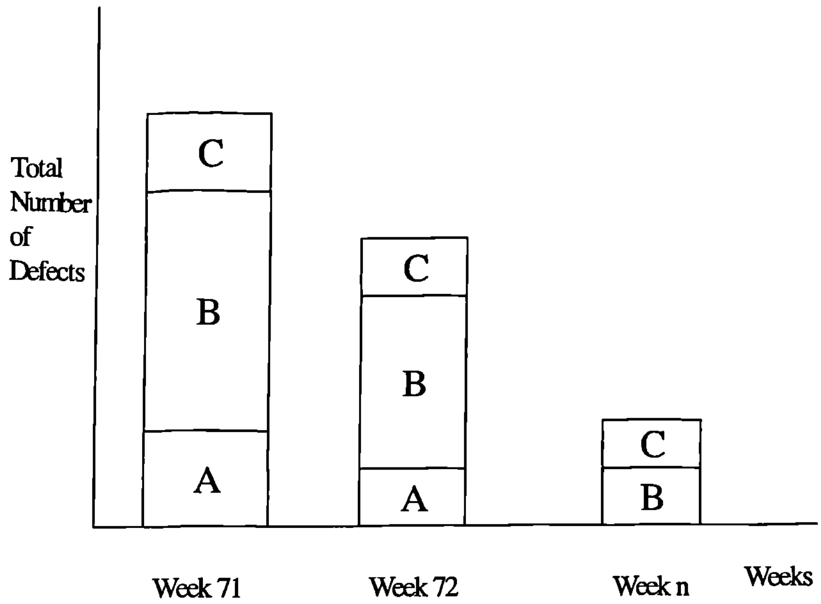

Figure 4-4, Problem Tracking

As seen in the above chart, the number of problems in each category is visible at any moment in time. It also shows whether the number of problems is declining, constant, or spiralling upwards.

Only a certain amount of problems (in each category) are allowed at each gate in the product development process. The logbook records the day the problem was discovered, the estimated solving time and the time taken for the problem to be solved. At each gate, a risk evaluation is undertaken and a new date is decided on for when to solve the unsolved problems. There could be recommendations to delay the start of production if there are too many problems. The whole risk is to be considered when deciding upon which problems to solve and how to solve them.

4.3.3 Legal Demands

Legal demands are very important and countries have their own legal demands. For example, emission requirements, etc. Products, and in this case cars, can be recalled if they do not fulfil the legal demands of the countries where they are sold. Yet, the legal demands are often ignored in the product development process in many cases. Legal demands also have fixed guidelines in the product development process. They have certain dates during which they must be certified. During the making of specifications the importance of legal dates is not kept in mind and the same is the case with liability issues[74] where a customer can sue the OEM. However, all liability issues cannot be considered, as many of them are difficult to judge. The OEM has to make a risk assessment and allow the product through.

Legal requirements not only cover current regulations, but also need to cover forthcoming regulations. For example, if a certain regulation[75] is to come in force in the next three years, then the OEM should be able to decide whether the current design should cover it or not. Legal demands could be in different spheres of the automobile, for example – in a power driven car, the key should be so positioned that the driver should not be able to turn it off. Different legal demands in countries may make it difficult to standardise the specifications. Legal demands could also mean that the specifications have to take certain issues for granted. For example, emission requirements in an automobile. This means that while on one hand there are restrictions, on the other hand, there is scope for creativity or innovation within these restrictions. There are currently no standards on how to write specifications. On the other hand there are standards like the ISO 9000, ISO 9002, etc., that help manufacturers to improve their processes.

4.3.4 Summary of the data on the specification process

I will now summarise the data on the specification process at auto OEM. In the specification process, it was observed that there were different departments that were involved such as Marketing, Research & Development, Manufacturing etc. The

[74] Officials in the auto OEM are afraid of the risk of liability issues in the USA, as it is one of the highest in the world.
[75] The California emission regulations are a good example as far as automakers wishing to sell in the USA are concerned.

involvement of these different departments in the specification process was detailed. The specifications were found to sequentially increase in content and the process started with the generation of the market segment specifications, which led to the IVTS, VTS, SSTS and finally the CTS. A number of intervening conditions to the specification process were also discussed. They were the directives, problem tracking and the legal demands. The legal demands were found to affect the character of the specifications. The time periods for the specification process were outlined. The time period was found to vary depending upon whether the car was created on an existing architecture or a new architecture; the latter consuming more time than the former.

4.4 Written Contracts in the auto OEM and the aircraft OEM

Observations indicate different types of contracts within the auto OEM. The aircraft OEM, on the other hand, has only one type of contract. For simplicity, the various types of contracts at auto OEM are designated as A, B, C, D and the contract at the aircraft OEM has been designated as E.

4.4.1 Contracts in the auto and aircraft OEM

Four different types of written contracts[76] [A, B, C and D] are utilised between the auto OEM and its suppliers in development projects. The aircraft OEM, on the other hand, utilises only one type of contract [E] when dealing with its suppliers. By examining these different types of contracts we will be able to analyse the different ways in which contracts are promulgated in the specification process between the buyer and the suppliers. The auto OEM contracts are explored at first, followed by the contract at the aircraft OEM. The contracts varied between one to fifty pages in the auto OEM and were ten pages long in the aircraft OEM. The first part of the data collection consisted of listing the discrete items that the different contracts contained. The result of this analysis is presented in Table 4-1, column A.

[76] There is no rationale as to why there are different types of contracts and also the type of contract to be given to a particular supplier.

	Column A: Items mentioned in the Contracts	Column B: Elements
Transversal items in all the auto OEM contracts	Price, service and quality are the important performance criteria for getting the business	**Performance Criteria**
	Suppliers must adopt Odette	**Communication**
Type A contract Auto OEM	The purpose of the contract was mentioned, which was in fact to use the suppliers resources to produce drawings according to the product development process.	**Purpose**
	The persons to contact were mentioned both at the suppliers end and at the OEM's end. Expenses to be calculated on an incurred basis.	**Communication**
Type B contract Auto OEM	The supplier should produce FLPS drawings. The supplier should produce NUFO drawings. Prototype parts to be produced by the supplier The supplier is responsible for all his sub-suppliers.	**Supplier Responsibility**
	The supplier should have full responsibility of the testing. Types of tests not mentioned in the specification should be agreed and determined by both the supplier and the OEM before the start of the test program. Test results are to be handed in to the OEM within a week after the tests.	**Testing**
	The OEM can cancel the contract at any time. If the OEM is responsible for the delay such as by enforcing late changes, the supplier is not liable for any penalties. x% of the final quoted price to be paid in penalty if the supplier does not fulfil the terms in the contract.	**Legal Issues**
	The OEM will give all information to the supplier regarding specification, description and drawings.	**OEM responsibility**
	There should be fortnightly project meetings The supplier should have a full time project manager and the capacity to provide a resident engineer if needed.	**Communication**
	The supplier should present to the OEM reports regarding compliance to quality targets. The supplier should inform the OEM about any existing quality problems.	**Quality Systems**
Type C contract Auto OEM	The supplier must submit service literature, parts and accessories, to the OEM at the same price as the original quote.	**Supplier Responsibility**
	No price increases are to be tolerated Cost, progress of tool and sample development must be followed.	**Communication**
Type D contract Auto OEM	The supplier is expected to deliver the drawings, specifications on x dates The supplier must give suggestions to the OEM	**Supplier Responsibilities**
	The personnel at the supplier should be organised so that they can work in-house at the OEM.	**Communication**
	In case the serial production is not awarded to the same supplier, the auto OEM will pay for the complete design work.	**Legal Issues**

	Column A: Items mentioned in the Contracts	Column B: Elements
Contract in the Aircraft OEM	Suppliers need ISO9001 certification.	**Quality System**
	Supplier should help the OEM market the final product	**Supplier Responsibility**
	Suppliers will be paid in case of termination Supplier liable to pay the OEM in case of delays	**Legal Issues**
	Changes to be negotiated in good faith.	**Changes**
	Price, service, delivery performance and quality are the important Performance criteria's for getting the business	**Performance Criteria**
	The suppliers must adopt Odette The suppliers must acknowledge receipt of messages and elucidate response dates.	**Communication**

Table 4-1, The Contract Data

In a second step of the data collection, 12 managers[77] -six from the suppliers and six from the auto OEM- were asked to meet in a focus group and to analyse the items contained in column A (Table 4-1) with the objective of identifying the important contract elements hidden in the listed contract items. The result of this step is exposed in column B in Table 4-1. A total of nine elements were identified: Purpose, OEM Responsibility, Supplier Responsibility, Testing, Legal Issues, Changes, Quality System, Communication, and Performance Criteria. Table 4-2 summarises the nine elements and indicates the extent to which they were present in the different contracts. Table 4-2 also provides an added value as it presents the nine elements in a sequence agreed upon by the 12 managers, in order to bring a better order in the contract structure.

ID	Contract Elements	Auto OEM				Aircraft OEM
		Contract A	**Contract B**	**Contract C**	**Contact D**	**Contract E**
1	Purpose of the contract	Mentioned	Not Mentioned	Not mentioned	Not Mentioned	Not Mentioned
2	OEM responsibility	Not clear	Mentioned	Not clear	Not clear	Not clear
3	Supplier responsibility	Not clear	Clear	Not clear	Not clear	Not clear
4	Performance criteria	Price, service, quality	Price, service, quality	Price, service, quality	Price, service, quality	Price, service, quality, delivery performance
5	Testing	Not mentioned	Mentioned	Not Mentioned	Mentioned	Mentioned
6	Legal issues	Not Mentioned	Mentioned	Mentioned	Mentioned	Mentioned
7	Changes	Not Clear	Not Clear	Not Clear	Not Clear	Negotiated
8	Quality systems	Yes	Yes	Yes	Yes	Yes
9	Communication	Not mentioned	Not mentioned	Not mentioned	Not mentioned	mentioned

Table 4-2, Contract elements sequenced

[77] The Managers from the auto OEM belonged to the Purchasing, Engineering, Projects, R&D, legal and Marketing Departments. The Managers from the supplier firms belonged to Marketing, Purchasing, Engineering, R&D, Projects and the CEO of the firm.

The elements are partly reflective of the background of the individuals in the focus group, but the final result emerged as a consensus after three rounds of discussions. It is to be noted that elements like specification – contract link (Harris et al, 1998) and payments (that are necessary for the supplier to remain in business by appropriately using his cash flow and managing his commitment to the sub suppliers; Leenders, 1993) were missing in the content of the examined contracts, and therefore naturally miss as main contract elements, while observed to be important in the literature review.

Further interviews were conducted to gain an in-depth understanding of the nine elements within the firms, and also to explore the specification - contract link. Given the technique of the open coding procedure, it was further decided to reduce the number of contract elements by regrouping. The coding, the categories and sub categories are as follows (Table 4-3). These categories will be examined one after the other in the analysis section.

ID No	Contract Elements [Main]	Contract Elements [Sub]	Reason for including the Sub Contract Elements
1	Types[78]		
2	Purpose		
3	Responsibility	OEM responsibility, Supplier responsibility, Quality systems.	Responsibility concerns both the supplier and the OEM; what are the responsibilities of each partner and what are the joint responsibilities? A good contract would need to specify this. The quality system that links the OEMs and the suppliers specifies detailed responsibilities both during development and during running delivery and production. I therefore consider that the quality system pertains to the category responsibility.
4	Performance Criteria		
5	Legal issues		
6	Communication	Changes	Integrated product development calls for extensive communication [Clark & Fujimoto, 1991]. Söderquist [1997], studying the role of expert suppliers in integrated component development, argues that operational design engineers and technicians invent their own communication modes and channels in an improvised and ad-hoc manner, and that appropriate support structures and guidelines for communication lack. Contracts could help in developing clearer communication paths. How and when design changes are dealt with is, to a large extent, a question of communication [Karlson, 1994]. I therefore consider the contract parameter changes as pertaining to communication.
7	Payments		
8	Specification – contract link	Testing	How testing of prototypes will be carried out is one of the main elements in a specification [Karlsson et al., 1998]. The contract can help in validating and checking testing procedures. I therefore consider that testing pertains to the specification - contract link.

Table 4-3, Regrouping contract Elements

4.4.2 Summary of the data collection on contracts

I will summarise the above data on contracts so that analysis can be facilitated. The analysis will be carried out in Chapter (6). As observed from the contracts in the auto OEM, there are signs that the contracts are different in content. The contracts in auto OEM have different characters, but it should also be noted that they are used for the outsourcing of the same type of components and systems. There is no clear strategy as to which contract should be utilised for which type of sourcing, i.e., component or system outsourcing. Hence, for the same type of project there are different kinds of

[78] Types refer to having one contract or multiple contracts for suppliers.

contracts. On the other hand, the aircraft OEM has only one type of contract, which is uniformly used across all projects.

The written contracts were utilised both in the aircraft OEM and the auto OEM as a commercial document that had no role to play in the specifications. The data from this chapter will be intertwined with the theory described in Chapter 2 to facilitate analysis. The next chapter is the analysis chapter on specifications followed by the analysis chapter on contracts.

5. SPECIFICATIONS - THE ARTEFACT AND THE CONTEXT

5.1 Introduction

This chapter is the analysis chapter of the research question relating to the role of specifications in the auto OEM. The literature review led to five detailed research questions, which will be examined in order. This analysis chapter will involve the amalgamation of both data and theory. The first research question that will be examined relates to the different elements that can be contained in a specification. The second research question that will be examined in on the effects of networks of suppliers on the role of specifications. After this, the research question dealing with issues faced with regard to the role of specifications will be examined. Then, the research question on creation of visions for suppliers and their effects on outsourced product development and core capabilities will be examined. Finally, the research question dealing with the development of a conceptual model to illustrate the role of specifications will be dealt with. The chapter ends with the conclusions summarising the most important results from the analysis. I will recall the research questions as follows:

1.	*What are the different elements that can be contained in a specification?*
2.	*What are the impacts of the network of suppliers on the role of specifications?*
3.	*What are the issues faced by OEMs with regard to the role of specifications?*
4.	*How can visions for suppliers be created and deployed leading to a positive impact on outsourced product development?*
5.	*What are the possible impacts that visions for suppliers may have on the core capabilities of an organisation?*
6.	*How could the role of specifications be illustrated with the help of a conceptual model?*

I will start with the first detailed question, namely the different elements that can be contained in a specification so that its role can be articulated in the same manner between the buyer and the supplier.

5.2 Meaning of a Specification[79]

Little attention has been given to the meaning of a specification. Getting a comprehensive view of the meaning of a specification will help conceptualise the elements to be contained in a specification. As a result, the literature-based definitions of specifications have been explored and now, the elements that can be contained in a specification according to the suppliers and the OEM firm will be explored. An open ended question (**What does the term specification mean to you when considering the activity/function that it is expected to execute?**) was asked to the suppliers (450) and the response rate from the suppliers was 54%. The responses from the suppliers are tabulated in Table 5-1.

ID	What does the term specification mean to you?	% of Suppliers mentioning
1	Requirements of the customer/user that the product has to fulfil	56%
2	A very detailed description of a product or a process	52%
3	Technical description of products and processes which may contain drawings.	50%
4	Norms which specify several characteristics of the part/system, etc., to be fulfilled in order to guarantee the good function and working of the part and, of course, in order to meet customer requirements.	45%
5	The specifications are a preliminary product performance requirement that allows the product to meet and survive satisfactorily "in use."	42%
6	Specifications are the description of a product and its properties as well as the methods of obtaining it. The methods could include details about the level of technology involved.	34%
7	Specifications are the summary of all important data, limits, methods, performance, targets, etc. Some of these parameters may be in the form of drawings.	32%
8	Defines the product properties that are necessary or will be measured.	31%
9	Specifications are technical regulations and drawings.	26%
10	Specifications are the requirements to meet the function.	20%
11	To manufacture in accordance with the customer requirement.	18%
12	A Specification is a vehicle for common understanding of requirements.	15%
13.	Any written communication is a specification.	14%
14	Description of process operations and acceptance standards.	10%

Table 5-1, Meaning of a specification

[79] Portions of this section have been published in Business Horizons. See Nellore, R. & Soderquist, K. & Siddall, G.& Motwani, J., (Nov – Dec 1999), Specifications: Do we really understand what they mean?, *Business Horizons*, 63-69

These different items describing the elements of a specification in Table 5-1 was discussed with the operational design staff and product development managers in the case study suppliers and the OEM. They shared the same definitions and agreed upon their relevance. This further analysis[80] resulted in a categorisation of the elements to be contained in a specification as presented in the following Table 5-2, which will be discussed as follows:

Category	Items describing the meaning of a specification
Communication	Transversal
Product Requirements	1,2,4,5,6,7,8,10
Functionality	2,3,4,7,10,11,13
Process Requirements	2,6,7,8,10
Standards	1,3,7,9,14
Drawings	3,7,9
Customer Requirements	1,4
Level of Technology	6

Table 5-2, Categorisation of definition areas[81]

- **Communication**

The specification is a document that is used to make a product. There are many changes that may be needed during the making of a product and many times a change in one part can affect the other parts as well. The specification is not a standardised document, but has to be updated continuously due to the changes. Hence, making all changes incorporated into the specification will lead to a quality product, as all-important details regarding the product, interfaces, etc., would be documented and not forgotten. Considering all written communication to be a part of the specification could help to improve communication. Reducing the number of redundant statements can strengthen communication, which implies that the number of errors would be reduced. Roozenburg & Dorst (1991) point towards reducing the redundancy in the specifications, as people are less apt to read specifications that are very long. Redundancy makes the specifications longer. It also implies that the rate of errors will rise if the specifications are long.

[80] Refer to appendix 5 for a complete overview of the manual factor analysis

[81] The above table shows that the perception of the term specification contains elements of both the document and the specifying process.

The suppliers were then asked to comment as to how many times the specifications had been changed (Figure 5-1) since they first received them. A little over 45% of the suppliers indicated that the specifications had been changed more than eight times since they first received them. Since the alterations were made to the same specification, it was clear that the auto OEM was not trying to work with sets of solutions and then narrowing them down, which according to Sobek II et al (1999) is a Toyota success factor. The auto OEM was instead following point based concurrent engineering and thereby, not using the specifications as a medium to communicate with sets of solutions. This resulted in delays to the launch of the final product. In other words, since the OEM was experimenting with only one solution considerable time had to be spent on debugging one solution, rather than using another solution from the shelf.

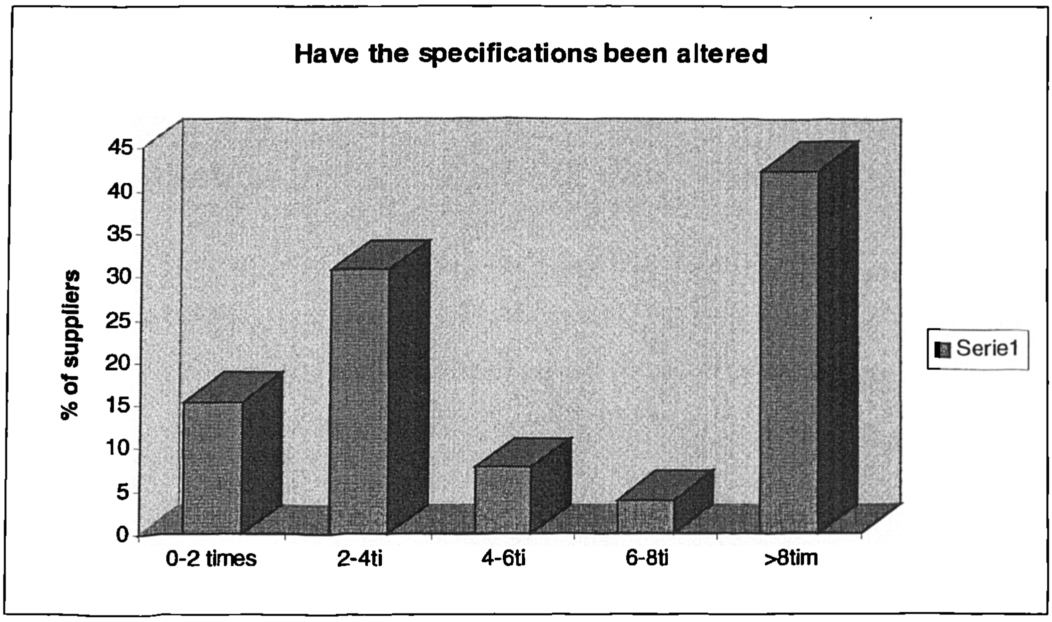

Figure 5-1, Specification Alteration Frequency

Wheelwright & Clark (1993) point towards four modes of communication, which have great significance in the relation between specifications and the suppliers. Involving the suppliers, classifying them accordingly and utilising the appropriate modes of communication as defined by Wheelwright & Clark (1993) can facilitate communications (Table 5-3).

Type of Supplier	Communication mode
Partner	Integrated Problem solving
Mature	Early involvement
Transition phase from child to mature	Early start in the dark
Child	Serial Interaction
Contractual	Serial interaction

Table 5-3, Supplier - communication mode interface

The partner suppliers work with concepts and present these to the OEM even before the OEM decision to start work on a project. However, there is continuous interaction between the OEM and the supplier both before and after the start of the project and thus there is a need for integrated problem solving. The mature supplier needs critical specifications to start work and hence, there is a need for early involvement, i.e., after the critical specifications have been fixed. The child and contractual suppliers need a serial mode of interaction, as they do not contribute in any way to the product design and instead just manufacture to specifications. However, the early start in the dark pattern can be used for suppliers who have been a child supplier for a considerable time and are transiting to becoming mature suppliers.

Specifications can be operational in order to facilitate communication. Roozenburg & Dorst (1991), who comment on the need to make specifications operational, confirm this. The specifications must thus, be communicated or written in such a way that they convey the same message to all concerned.

Once the specifications have been submitted, they can be discussed in order to avoid misunderstandings. There is a need for effective communication and in most cases face-to-face communication is the best for solving problems. More discussions and early work could be done before the specifications are to be implemented. Multiple communication techniques can be used, for example, written confirmations after a telephonic conversation to officialise the matter, seminars to discuss the specifications, etc. Also, there needs to be regular review meeting and liaison work so as to understand each other's capabilities and requirements/limitations.

- **Product requirements**

After the market demand is known, an overall specification is generated which is later broken down to the system level and the component level. The supplier usually handles the component specifications and, in some cases, the system specification. The specification may cover the description of the product that could be a narrative description to get a feeling of the product, or a technical description of the product to allow satisfactory "in use". Specifications need not only mention the end product, but also the ways and means of getting the end product. This is also confirmed by Smith & Reinertsen (1991), who state that specifications are the means to the end. One of the most important requirements is to examine whether the product will work satisfactorily and that would mean that the product properties to be measured must be known in advance. In other words, *what is going to be measured.* The targets that the product has to fulfil (cost, quality, lead-time etc.) are to be included in the technical description of the product. The above analysis confirms to what has been pointed out by Rozenburg & Dorst (1991), that the specifications should contain quantitative measurement indicators demonstrating that the requirements and benefits have been met to the extent needed by the customer.

- **Functionality**

A product has certain functionality's and features that need to be implemented. The specification may contain a list of these features and the requirements in order to meet the functionality. Many times the partner suppliers can be given a free hand in deciding the requirements to achieve the functionality as stated by the OEM. An example of a functionality would be when the OEM communicates to the supplier as follows: "to *have an audio system that is within the brand of the OEM and is of premium quality to the end user of the car*". The above statement contains few details and allows the supplier to interpret. This also means that it cannot be given to all types of suppliers, i.e., if the suppliers' capabilities are lower than what is required to interpret such a functionality specification. The analysis indicates that the specifications that are handed out to the suppliers are dependent on the type of supplier. While partner suppliers are handed out statements on functionality, the other types of suppliers are handed out specifications based on their capabilities, for example, detailed drawings to the child suppliers, etc. This certainly deviates from the findings of Smith & Rhodes (1992), who comment on thirty two different elements[82] in the specification, whereas the analysis indicates that the composition of the specification is variable and could be more or less than thirty two.

As there are different types of suppliers (Kamath & Liker, 1994) the level of detail in the specifications can be varied. As the level of detail increases, the functionality specification becomes a detailed specification. In other words, the normative nature of the functionality specification transforms into detailed parameters and quantitative numbers. The transformation from qualitative to quantitative specifications[83] is costly to a company as will be illustrated below. It also dictates the type of suppliers that will be required.

Smith & Reinartsen (1991) elucidate that the reason behind specifications having no focus on purpose could be the fact that people are uncomfortable with narrative statements. The argument can be extended to state that specifications are on a continuum from narrative to quantitative statements and there is no need for all the crucial elements in the specifications to be quantitative all the time. For example, styling specifications, which makes it so that the customer feels safe in the car, feels at home in the car, etc., are purely narrative and cannot be described in quantitative terms. The feel of the car that the customer experiences depends on the experience and knowledge of the people working in the styling department of the OEM. The point of disagreement with Smith & Reinartsen (1991) is that while they comment on the fact that not all factors in the specifications are quantitative, this study indicates that there is no need for all the factors in the specifications to be quantitative, and that the specification factors operate in a continuum from being narrative to quantitative as will be illustrated in Table 5-4 below.

[82] It is interesting in the sense that the authors have tried to generalise their findings of 32 elements to all projects. I want to convey the fact that the "magical number" 32 is not important rather the incorporation of all the necessary data in the specification (based on the capabilities and capacities of the suppliers) is important.
[83] The examples of qualitative and quantitative specifications are those that were observed in the case company. As a generality this is flawed.

Narrative	Mixture of normative and quantitative	Quantitative
• Styling: To feel at home in the car	• Chassis: Driver in command could be the normative part as the design of the chassis must ensure this. Quantitative part: Actual chassis elements, composition etc.	• Components like nuts and bolts
• Sound: Nice and harmonised balanced reproduction of sound.	• Noise vibration harshness: Normative part is the total harmony of the vibration in the car etc., Quantitative part: Sub-frame etc.	• Brake disc
High	Hard to simulate	Low
High	Complexity	Low
High	Subjective judgement	Low
Low	Level of detail	High
Low	Resources required	High

Table 5-4, The specification continuum[84]

Table 5-4 shows that specifications are actually on a continuum from being completely narrative to completely quantitative. Styling, sound, etc., are some of the items that can be expressed only in narrative terms. Others like brake discs, nuts and bolts can be specified purely in quantitative terms. Chassis, noise vibration harshness, etc., generally use a mixture of both quantitative and narrative approaches. However, there are a number of dimensions when considering the continuum from low to high. The complexity of the product is low when it can be expressed purely in quantitative terms and the complexity is high when it is only possible to specify the product in narrative terms. The simulation tests that are carried out for the whole car as opposed to testing parts independently, for example, an independent radio test as opposed to testing the radio when the car is running, becomes harder as one moves to the narrative dimension from the quantitative dimension due to the subjectivity associated with narrative statements. The level of detail increases in the quantitative dimensions, as everything will have to be specified. That implies that the specifications will run into thousands of pages. This would also mean that the resources for generating a

[84] The examples used are company specific. Further details can be found in the paper published in Omega.

quantitative specification would be substantial. The judgement becomes subjective with narrative statements as the validation depends on a few key reviewers in particular departments. As observed in the above discussion, there needs to be a trade off between using quantitative and narrative specifications.

- **Process requirements**

The specification can cover the process requirements that will be used for the manufacture of the product. Many times the product can be given to a supplier whose process does not match the product. Hence the process requirements can be mentioned in the specification, so as to validate that the product can be produced in the manner required by the customer. For example, audio suppliers should use automated diagnostic for checking the printed circuit board. This allows for early rectification and reduction of scrap and improvement of quality. The process can allow a certain degree of flexibility in order to make late changes.

- **Standards**

The specification can include the standards that are to be followed. There are standards for components, for example, all edges on anything that is located within the panel area in the car should have a radius of 2.5 mm minimum. There are also standards for parts, within the components, for example, mercury cannot be used, certain types of glues are not allowed, etc. There are legal standards, performance standards, country standards, etc. Understanding and knowledge of all the different standards can help prevent late changes. All possible legal guidelines, dates for certification, liability issues may have to be identified and a problem tracking undertaken in order to get the development process progressing without barriers. There are standards for the processes used for the manufacture of components, for example, the printed circuit board should be cleaned with citrus fluid. Smith & Rhodes (1992), who identify thirty-two different primary elements of a specification, also mention standards. Standards are an important component of specifications and can be used in the dialogue with suppliers. While partner suppliers are expected to be knowledgeable in the standards, all the other types of suppliers may require express communication of the standards so that they understand them.

- **Drawings**

A specification also contains drawings due to the fact that many features in the specifications need pictorial explanations. Drawings contain details that cannot be put in a written specification and are the outcomes of specifications and not vice versa. The auto OEM sustained losses[85] in generating the drawings first and then writing ten to fifty pages of technical regulations to supplement them, as opposed to the top down approach where the specifications led to the drawings. The need for drawings increases as one moves towards dealing with child suppliers (classification of suppliers are as defined by Kamath & Liker, 1994) as opposed to partner suppliers. For partner suppliers, many times drawing/s are not given and instead the supplier is expected to make his own drawings. For a child supplier, the only items in the specifications are the drawings. Finally, the drawings are very important for child and contractual suppliers, as shown in Figure 5-2.

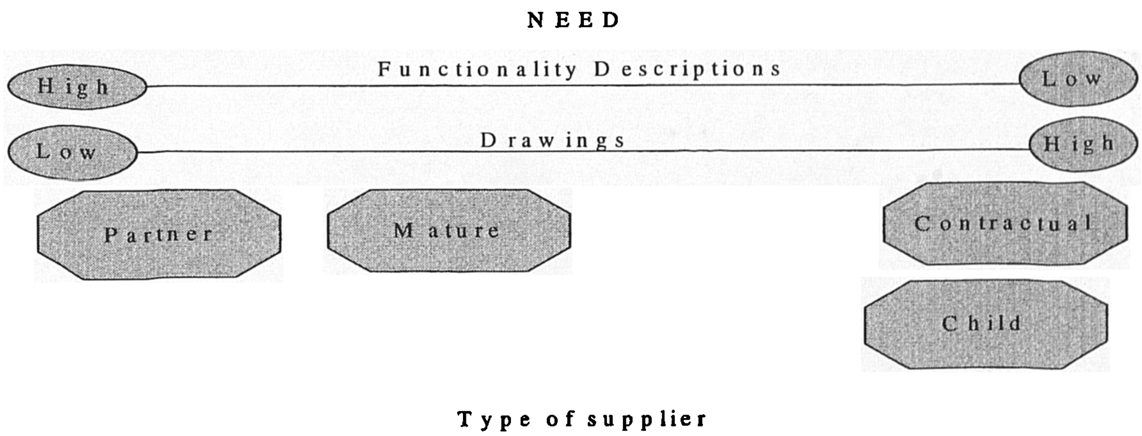

Figure 5-2, The continuum from narrative to quantitative specifications

[85] Losses were observed in terms of travel costs, increase in the prices that what was negotiated with the supplier/s.

- **Customer (OEM) requirements**

The specification needs to cover the requirements of the OEM. When the OEM gives a specification to the supplier, it implies that the requirements of the OEM are to be fulfilled. In turn, the requirements of the OEM are generated from the needs of the final customers, i.e., the people who buy the final product. The specification needs to incorporate special requirements of the customers (OEM), for example, if the customer wants batches/JIT delivery, etc. This is in line with the conclusions made by Smith & Reinertsen (1991) who state that the customer benefits need to be focused on. Suppliers can consider the benefits of the product that they make, not only for the OEM but also for the final consumer. Hence, there needs to be a customer requirement - customer benefit discussion indicating that the specification could be used a working document. This also confirms Smith & Reinartsen's (1991) conclusion that non-usage of the specification as a working document could lead to delays in the development process. This discussion indicates the need to satisfy not only the customer (OEM) requirements, but also provide benefits to the customer. For example, the final customer requirement might be a car, but the OEM can satisfy the customer requirement and also provide a customer benefit such as a microphone that allows interface with the customers existing telephone. The supplier of the telephones to the OEM can satisfy the requirement of the OEM by providing a microphone and can also provide the final customer a benefit by allowing the microphone interface possible to a number of different brands of telephones. The requirements and benefits stated in the specification can be comprehensive, as indicated by Rozenberg & Dorst (1991), so that they are easily understandable and contain an overview of the product that the specification is poised to create.

The content of the specifications needs careful selection or there may be inconsistencies, inaccurate data, misleading information, etc. This points towards the conclusions of Smith & Reinartsen (1991) that the specifications have to contain the customer requirement, the customer benefit and should be representative of a carefully thought out trade-off between the different specification elements. This means that a clear emphasis on the content and reflection on the customer benefit-customer requirement discussion is necessary in order to get a good working specification. The content of the specification can be helpful in overcoming problems like individual backgrounds affecting the specifications, as proposed by Rosenau (1992). If the customer benefits, customer requirements, understanding of the technologies and their effects on future customer needs, etc., are clearly laid out from the beginning, then the chances of different backgrounds affecting the specifications is minimised even though the specifications are the result of group work between many different functions within the organisation.

- **Level of Technology**

The statements on functionality can consider the level of technology involved, which is also confirmed by Aoshima (1993). If the technology can be developed for a component /system without knowledge of the interfaces, then the specifications need not have details about the interfaces. On the other hand, if the technology to be developed needs knowledge about the interfaces, then the specifications can regulate that the necessary details are available. The capability level of the supplier would be a significant factor in determining how the suppliers interpret the knowledge about the interfaces. Mature and Partner suppliers would take the lead and start direct talks with the suppliers of the component/system interfaces. On the other hand, child suppliers and the like would need drawings, which include all possible considerations of the interfaces.

As the industry moves from being vertical to horizontal (Fine, 1998), the requirements on the specification also change. For example, the specification requirements are different when the auto OEM makes its own raw materials, parts and components and assembles them rather than outsourcing everything. If firms do not understand their industry structure, then they would be over/under managing their suppliers. The specifications can consider whether the technology is static or dynamic which Hollins & Pugh (1990) also indicate. Even within certain parts there can be a combination of both. If this difference is understood, then the work can proceed faster as the static parts can be worked on with no further delay. A lot of tests, simulations, prototyping, and tolerances on parts will give the staff from the different departments an ideal opportunity to understand the part that they are dealing with and thus the project can secure the commitment, understanding and sympathy of all concerned. The non-understanding of the link is evident when one observes the auto OEM giving detailed specifications to systems suppliers. One possible explanation could be the fact that the specifications from the Fordism days of vertical integration are still widely used. The above discussion indicates the presence of both static and dynamic parts in the car.

5.2.1 Concluding Discussion

The conclusion reached after the analysis is that the specification contains several elements that could be fulfilled either by the OEM or the supplier or both, depending upon the type of supplier and the communication pattern used. What is important to note is that the suppliers are to be handed out specifications based on their capabilities so that they are able to understand it. One or more elements can be combined with each other, for example, a component supplier can simply be given a drawing which contains all the other elements. The assumptions are thus clear and the OEM has carefully considered all the elements in the drawings. A partner supplier on the other hand does not need a drawing as he is expected to create the drawings and work with functionality descriptions. Referring back to the other theoretical definitions on specifications like written description of products to guide the development process (Smith & Reinartsen, 1991), it is clear that the specifications can guide the development process if they can satisfy the eight elements mentioned above. The eight elements indicate that the understanding of what constitutes a specification corroborates the finding of Hollins & Pugh (1990) as it represents the chain of activities that start from the need identification to the satisfaction of the need. Bad elements or non-existence of these elements can lead to increasing costs.

5.3 Networks and the effect on specification work

The clear signal from the above analysis- that suppliers need specifications based on their abilities and capabilities-can be developed further with reference to the network theory which is the second detailed research question that was laid out at the start of the study. In order to better understand the connection between the suppliers and the specifications, I will consider the key elements of the supply network strategies (Figure 5-3) as proposed by Harland (1996), namely end customer, competitive priorities, supply network structure and supply network infrastructure (in shaded boxes).

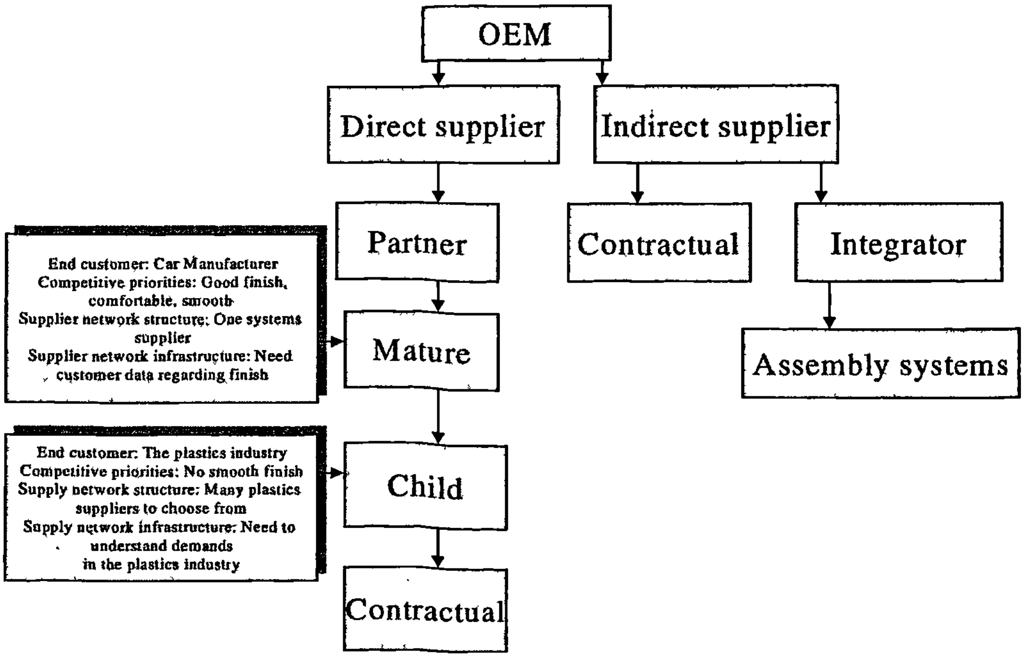

Figure 5-3, Network of suppliers[86]

The auto OEM deals with two types of suppliers, namely the direct and indirect supplier with respect to the product. The direct suppliers deliver components/systems while the indirect suppliers deliver assembly systems and shop floor equipment/tools. Process suppliers can be both second tier and first tier suppliers to the same OEM. In the final assembly area, most of the work is done with hand held tools and hence the process suppliers delivering power tools to the auto OEM are acting as first tier suppliers. On the other hand, in the assembly systems area they could also act as second tier suppliers if they deliver components used in the assembly systems to a final supplier who puts the cabinet, cables, etc., and delivers it to the auto OEM. It is essential to involve the assembly systems suppliers from the time the design process is started otherwise there could be mounting problems (difficult to mount parts in the car). While the partner supplier may have to consider the involvement of indirect suppliers early enough, the mature supplier, in conjugation with the OEM, needs to consider the early involvement of the indirect suppliers in case the OEM does not have any partner suppliers. There can be a network of suppliers organised according

[86] The network of suppliers shown can be used for the development of a single system/module/complex component.

to the specification process. Partner suppliers know the needs and demands of the OEM, the pertinent interfaces, and hence may have to work with a number of concepts in order to reach the required level of partnership. The auto OEM can have a limited number of partner suppliers covering all the subsystems that constitute the car. The partner suppliers can, in turn, have a number of mature suppliers who can build subsystems as well but need critical specifications to develop their sub-systems. The mature suppliers can, in turn, have a number of child suppliers who make small assemblies that constitute the sub-system. The child suppliers, in turn, have a number of commodity suppliers. However, the network needs to be carefully managed, otherwise it could lead to problems in quality and lead-time and ultimately in profit.

I will take an example (with reference to Figure 5-3) to prove the point. The different types of suppliers are adopted from Kamath & Liker (1994). Partner suppliers are expected to work with different concepts in an independent capacity, mature suppliers need critical specifications to begin their work, child suppliers need detailed specifications and lastly, contractual suppliers are those who make standard parts that can be ordered from a catalogue. There was no partner supplier and instead there was a mature seat supplier dealing with the auto OEM. The seat supplier had a number of child suppliers working for him and one of these child suppliers was an arm-rest supplier. The arm-rest in the car comes under the sub-system of interior and was given to the seat supplier. The plastic supplier (from another industry) supplied an armrest that did not match with the smooth interior of the car, which required a plush finish as it was operating in the premium segment. Hence, if the child (plastic) supplier is from a different segment, then the specification needs to take it into consideration. Similar problems were also observed in the development of the radio. The drawings clearly indicated that the knobs on the radio were to be centred, but the written specification did not mention this. This resulted in the knobs not being centred on the radio. The child suppliers can impact the final product if the requirements of the OEM are not explained to them. The problems that arose due to the child supplier are also what Håkansson (1987) describes in his analysis of product development. Technological development of one actor can affect the others in the network and this was exactly what happened in the above case. If firms identify the critical actors in the network and characteristics of their activities, as pointed out by Håkansson (1987), then the chances of such problems occurring are minimised.

5.4 Issues with the Existing Role of Specifications[87]

The discussion in this part will illuminate and conceptualise the issues faced by the auto OEM and its suppliers with regards to the role of specifications. Karlson (1994) clarifies that most of the research efforts in product development do not take into account previous design efforts. Relating his observation to specifications, it becomes obvious that it is important to understand the previous efforts in specifications if one is to improve it or develop newer ways of developing the specifications. The suppliers (450) were asked an open-ended question **"What are the issues faced with regard to the role of specifications?"** The responses are tabulated in Table 5-5.

ID	Issues	% of Suppliers Mentioning
1	Specific requirements often lead to specific versions. There is not enough standardisation, which increases cost.	10%
2	Sometimes there is no cost optimisation	32%
3	Sometimes the specifications are too general and do not cover the requirements of the part in question.	23%
4	The OEM does not give reasons for changes in specifications to the supplier.	35%
5	Even when it is very urgent, some specifications are missing such as tolerances and dimensions.	15%
6	There are problems in interpretation of specifications as well as in language translations.	49%
7	Specifications keep changing all the time. • Specifications are even changed after tooling and method of manufacture have been decided.	52% 28%
8	Sometimes the specifications are gold plated. There are a lot of opportunities to add more costs.	15%
9	OEMs do not listen enough to the expertise of suppliers. For example, too much cost saving in the design might lead to poor satisfaction of functionality in several cases.	29%
10	There are extremely short lead times.	22%
11	There is a lot of over specification, which increases the cost. For example, : • The tolerances are too narrow • Some of the criteria are well beyond the life usage of the product	35% 15% 20%
12	New specifications are not discussed in the planning stage	16%

Table 5-5, Issues identified through the survey

These different issues were discussed with Product Development Managers and operational design staff in the case study suppliers. They shared the same problems

[87] Portions of this section appears in the Journal of product Innovation Management, See Karlsson, C. & Nellore, R. & Soderquist, K., (1998), Black Box Engineering; The Role of product Specifications, *Journal of Product Innovation Management,* Vol.15, No.6, 534-549

and agreed upon their relevance. This further analysis[88] resulted in a categorisation of issues presented in Table 5-6. Item 10 in Table 5-5, short lead-time is a transversal factor influencing all of the above categories.

Category	Issue Area
Technical Content – Level of detail in requirements	1,3,5,8,11
Changes of Specifications	4,7
Cost	2,8
Participation of the suppliers in the specification process	9,12
Interpretation and Understanding	6

Table 5-6, Categorisation of issues[89]

- **Technical Content**

Two main problems existed concerning the technical content of the product specification. The first problem was that specifications sometimes were very general and vague and did not cover the requirements of the specific part or product in question. This was true in the case study supplier firms where design technicians sometimes complained that specifications were incomplete, something that considerably delayed and increased the cost of operational design work as they would have to spend extra time and money trying to decipher the meaning of specifications.

However, behind the expression "the specification is not complete" one may ask the question whether the specification ought to be more complete (Soderquist, 1997), i.e., if information has been left out by error at some stage in the elaboration or transmission of the specification, or if the specification was intended only as a guideline that the customer didn't wish to specify further. This problem was related to the transformation towards general guidelines and guiding visions rather than detailed instructions in the customer-supplier interface in product development - identified as

[88] Refer appendix 5 for a complete overview on the manual factor analysis.
[89] As can be noted from the table there are categories representing the document (Technical content, cost, interpretation and understanding) and the specifying process (changes in the specifications, participation of the suppliers in the specification process).

black box engineering. Karlsson & Åhlström (1996) make similar observations in their case study of an international manufacturing firm producing mechanical and electronic office equipment: "Requests for detailed specifications were regularly observed in the different projects. [...] The specifications that were requested should contain fairly detailed descriptions of the product. Specifying the functions the product should perform was not enough" (p. 290).

The present research provides a complementary picture of the process of specifying in black box engineering. Indeed the study reveals a general problem for design engineers to determine in which category different specifications belong, but project members at the two supplier companies did not have any particular problem with developing new product solutions out of only partially framed specifications. What was perceived as a problem was knowing when a design demand concerned a black box type of product or a more detail-controlled one. Several examples were quoted when a design problem was seen as pertaining to the first category, but the reaction to proposed solutions would be negative on the part of customers with the pretext that detailed specifications existed for the component. In such a case the OEMs clearly bore the responsibility for the misunderstanding. The most important cause behind this problem found in the study of the OEM was that the latter, after having sent out a request containing framing specifications, often got delayed in the further specification of the component in question. This because of system integration difficulties related to modifications in other interfacing components. On the supplier side, a one-week silence from an OEM combined with a defined lead-time in the initial draft specification resulted in a launch of a development project thinking it was question of a black box study.

The second problem concerning the technical content was related to over-specification. Many times the correct tolerance level was not mentioned or very narrow tolerances were given. Too narrow tolerances could mean that a product cannot be made and thus unnecessary time will be wasted in changing the specifications and coming to a realistic tolerance level. In some cases, the content (e.g., functional solution, material, dimension) of a specification can be "extreme", i.e. very hard or even impossible to realise with existing technology. The main reason behind this was found to be the fact that there is often no time to involve internal or external experts when new innovative propositions are developed. The result will be the birth of a very costly product, or worse a specification that cannot be realised or a product with a no operational use (for example, a product that cannot be integrated with other technologies in a system).

As illustrated in the above discussion, the specifications are too detailed in some cases, and in others they are not detailed enough. Hence, the supplier risks being tied up and losing precious development time and money. The main cause seems to be an information gap in the buyer-supplier interface concerning the exact capabilities of different suppliers.

- **Changes of Specifications**

According to the suppliers, there are too many changes in the specifications. Too many changes means rework, thus delaying the product development process. Changes could be due to a number of things like mistakes, no harmony between various demands within the OEM's different technical centers and the need for interaction in the functional system, etc. Often the reasons behind changes in specifications are not mentioned to suppliers, thus making it harder for them to adapt and optimise component characteristics and to understand the implications that the changes might lead to in relation to the evolution of a system. A particular form of late changes occurs if mistakes once noted have not been corrected back into the specifications. Major delay and cost problems can be expected if the changes in the specifications are made after the supplier has set up the tooling. This would mean that the supplier has to retool, thus increasing the cost. The OEM has tried and tries to reduce the product development time. However, in doing so they underestimate the usefulness of testing. If the case study OEM invested in testing out prototypes thoroughly before suppliers engage in serial tooling, then it could reduce this risk and save both time and money.

Even though the specification was often seen by design engineers in the supplier companies as *one* relatively *fixed* document, observation of the activities taking place between the initial receipt of a specification and the moment when it was considered as completed, indicated that specifying in black box engineering is a *process* taking place at the *systemic level* of operational design work, i.e., involving project teams in customer and supplier firms as well as development teams in suppliers of interfacing components. It always needed further interaction with the customers, cross-functional consultations inside the supplier companies, and often the advice of experts such as sales engineers or research staff as well. These observed tendencies have strong parallels to the recent research on the use and management of specifications reviewed above. They confirm the propositions from Kaulio (1996) also concerning the designing of automotive components: the specification is an arena for co-operation and a series of documents that are generated by the totality of the involved actors.

What actually happened in successful black box engineering projects that were identified was that a set of different specifications was developed based on the initial framing guidelines transmitted by the customer. This practice resembled the practice at Toyota suppliers described by Ward et al. (1995). This contained nothing revolutionary in itself; design technicians generally developed several product solutions and prototypes for every new development project, so the "raw material" for such a line of action already existed. What was changing in both supplier companies at the moment of the study was that these parallel solutions (in the form of blueprints, prototypes, different text documents), were successively presented to the customers. Traditionally, the different developed solutions were evaluated inside the supplier company and only the final chosen solution was presented to the customer.

- **Cost**

Why are cost targets so difficult to agree upon between OEMs and suppliers? First of all, a trade-off was identified within the OEM. When the technical content is specified, engineers and marketing managers tend to think mostly in terms of technical performance - innovativeness, and setting new market standards. When purchasing set cost targets, they think principally of the overall project budget. The problem facing selected suppliers is then that there might be an important mismatch between technical content and cost target.

Secondly, there are issues related to the content problem discussed above. When black box specifications are given to suppliers, they are generally about 60-70%

complete and hence subject to change. As discussed earlier, the suppliers do not always understand this fact. They quote a price for this 60-70% specification on the assumption that this is 100% of the specification and thus demand compensation for every change proposed by the OEM. There are different opinions about specifications between the suppliers and the buyer. The OEM doesn't want suppliers to change their prices or to ask for increased compensation for every change. On the supplier side, however, there is another interpretation to this. According to the suppliers, it is impossible to estimate the changes required at a very early stage and thus difficult to quote a price including the unforeseen changes as well. Sometimes the cost book price may also be wrong.

The third cost related problem concerns the lack of cost optimisation and the opportunities of adding more costs that affect both suppliers and OEMs. Many times the specifications are so written that it is very easy for the suppliers to add costs. The specifications leave large gaps for interpretation concerning material, functions or levels of tolerances. If there is no time or relevant links available for checking up on ambiguous or apparently missing information, suppliers might end up over-designing components, thus increasing cost both for them and the OEM. For example, the OEM had to incur a loss of 5% due to the fact that a supplier used a particular material that was 10% more expensive than originally planned by the OEM. The OEM refused to pay the 10% increase and accepted only a 5% increase, leading to a shrinking margin for the supplier and an increased cost for the OEM. Also, many times the defined specifications are far beyond the life usage of the product thus adding on more cost.

- **Participation of Suppliers in the Specification Process**

Several of the problems in the product specification process were related to a lack of early and/or in-depth participation of suppliers in the development process. In spite of the discourse and development of tools and methods presented in the product development literature, this study indicates that this is extremely difficult to achieve in practice. An important conclusion of the study is that the project organisation in all OEMs and direct suppliers today is insufficient for ensuring rapidity and relevance in information exchange. For example, an initial question from a supplier design technician concerning an ambiguous issue in a product specification first has to pass via the project manager in the supplier company, then through the suppliers sales engineer, and finally through the function project manager in the OEM, before reaching the design technician concerned. This caused at least two problems in the studied supplier firms:

- The design technician in the OEM would not return information that was 100% relevant in relation to the original request;
- Implicit elements in the initial message and in the answer might disappear.

It is important to emphasise that the problem of information transmission wasn't related to deliberate withholding of information, but to a distortion due to the fact that different actors did not perceive a question in the same way. Another example where lack of supplier involvement causes problems is in the setting of overall technical targets for a system. If suppliers are not involved in this process, their solutions can easily jeopardise the overall performance of a system. An example of such an overall technical target is weight limits. Since weight falls in the critical path of the product, the involvement of the suppliers would be only beneficial as they can help reduce the weight and thus contribute to the overall performance of the vehicle. This corroborates with the findings of Clark (1989). A problem observed in the OEM was that weight requirements were rarely included in the specifications, thus suppliers sometimes increased weight, which could lead to overall weight problems. Even though weight is a very important requirement in the automotive industry, neither the OEM, nor the case study suppliers had a separate department or function looking into the weight issues and trying to reduce the weight throughout the car.

These different interface problems are intimately related to the question of how information is transmitted between customers and suppliers during product development. When the supplier is working on black box or own proprietary development projects, there is a need for very frequent information exchange for mutual adaptation and evolution of interfacing components. Field observations and the problems analysed above indicated that information exchange at the project level, as prescribed by organisational routines, was not enough for ensuring optimal integrated development. Through the case studies, a specific way of communicating at the individual operational design engineer or technician level could be observed. This exchange of information with customers, short-cutting formal routines, was very frequent and broad banded, i.e., concerned issues that at a first glance sometimes looked quite distant from the actual activity performed by the engineer or technician. Through this information exchange, accuracy in technical discussions was improved and lead-time reduced. Moreover, it allowed for the participants on both sides of the interface to learn about new practice that could be transferred to other parallel projects.

Other important actors also come into the picture of designing black box parts, namely suppliers responsible for interfacing components evolving simultaneously. For the studied companies, their integration in the development process caused as many problems as that of integrating with customers. It seemed that the system co-ordinators did not fully master this complex integration process -that only recently had emerged- but that tends to become more and more important. In addition, the participating suppliers were normally less focused on their horizontal colleagues than on their vertical customers.

The research findings indicate that the systemic nature of design work draws managerial attention to integration between participants in the design process. With an increasing number of interfacing actors, both external and internal, the demands for efficient co-ordination also increases. Through the change in the industrial organisation towards more inter-company collaboration and concurrency in the development process, suppliers have been taught the need of integrating both internal operations and external inputs the "hard way." Integration has become the inevitable means to an end for remaining an expert supplier to the carmakers. However, at the same time that systemic work is a driver for integration, it is also a facilitator: peoples' minds will turn towards more of an outward looking perspective because they will understand the sense of communicating and informing through their own need for information coming from others.

- **Interpretation and Understanding**

Shrinking development lead-times is a daily concern for development staff in both OEMs and suppliers. OEMs want to exercise any option that may help in reducing lead times. When a lead-time is defined, it is supposed that the product specification is complete, the supplier will know how to act, and no more changes will occur. However, as our study has shown, this is not necessarily the case. In reality, this means that within the frame of a theoretical minimised lead-time, there will be elements of delay in terms of modifications, wrong interpretations, and insufficient information exchange. The result is that suppliers often find themselves in a vicious circle of delays that add up from project to project and from customer to customer. The consequences are continuous rescheduling, insufficient prototype testing and hard prioritising following the largest customer or the one that asserts the most pressure.

Observations of specifications sent out by the OEM and received by the suppliers show that sometimes the specification is full of words with little focus on purpose - it is thus difficult to understand. This means that the responsibility for the specifications is pushed around within the organisation and this corroborates the findings of Karlsson & Åhlström (1996). Language and translation problems can be other causes behind misinterpretations, which also adds to the list of reasons behind bad specifications according to Hollins & Hurst (1995). Wrong understanding or translation can mean that the critical aspects of the process can be misunderstood. If most of the specifications are not discussed early enough in the planning stage, there will be a lot of iterations towards the end of the product development process. There are communication problems between the supplier and the buyer about the specifications. In the worst case, suppliers do not even read the specifications properly. Problems with interpretation and understanding arise not only between the buyer and supplier, but also internally within the OEM or within the supplier. Different people create the different layers of specifications, for example, the marketing specification, top level of specification, system specification and component specification. The people involved do not read whether their requirements have been fulfilled or not in the requirements flow-down which results in certain demands not being fulfilled. The realisation comes when the product is ready and it is too late to make any changes. If changes are made at this late stage then there will be cost increases and increased time to market. The communication patterns are thus distorted due to lack of feedback between the different layers involved in the requirement flow-down.

5.4.1 Implications for the specification process

The problems faced in the specifications by both suppliers and the OEM were examined. In order to overcome the specification related problems which by themselves are interesting to anyone involved in the management of specifications, a specification-supplier framework is proposed. There are no general rules for success as there are many factors such as the environment, nature of the product, the previous knowledge of the partners, etc., which can affect the relationship with the supplier. However, the framework can help companies to assess and reflect on their specification management and ultimately improve and sustain it. The proposed framework is presented in Figure 5-4. It comprises the items analysed above and adds three factors, control and limitations that constitute direct governance links for the specifications and prototypes that constitute the tangible artifacts exchanged between buyers and suppliers as a result of the specifications. The framework is not exhaustive but exploratory.

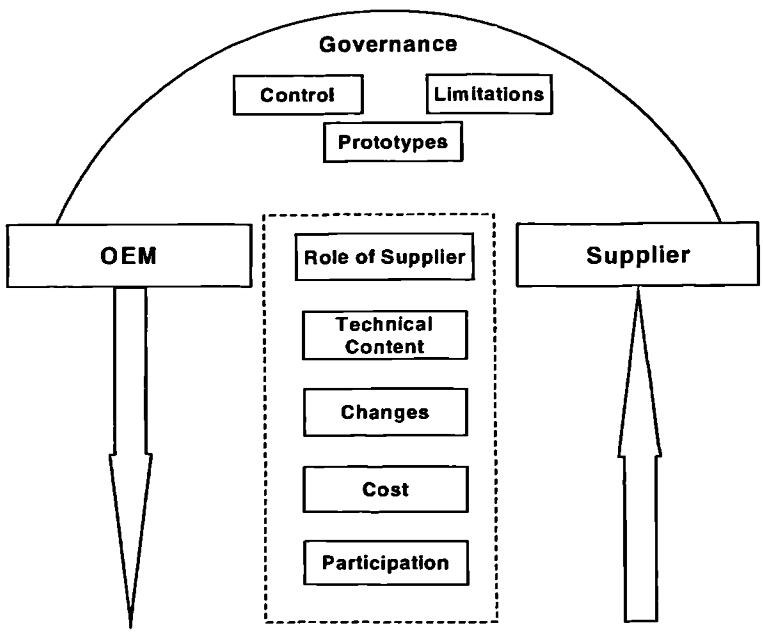

Figure 5-4, Specification - Supplier framework

Figure 5-4 displays a set of factors and governance mechanisms[90] that the OEM and the supplier may consider in order to improve the development process. The central box contains factors of high importance to regulate between the two parties and the upper box contains important mechanisms to govern the relation as follows. Both the OEM and the supplier can decide on the role to be played by the supplier. The technical content of the specification is a reflection of the capabilities and capacities of the supplier and thus would play an important role in the factors that can help improve development. Factors like cost, changes and participation on the part of the supplier may contribute to improved development. Control, limitations and prototypes form governance mechanisms that help to regulate the relationship between the OEM and the supplier.

- **Role of the Supplier**

Firstly, the role of the supplier needs to be defined. Different types of suppliers have different roles and hence the content of the specifications would be different in each case. In this case we are interested in the role of black box suppliers[91], i.e., the suppliers who are given critical specifications that frame the component or systems requirements and call upon the suppliers' innovation and development capability. A confusion in the OEM about the capabilities and competencies of suppliers leads to their over or under management.

These studies have identified tendencies that challenge the generally accepted tier model where first-tier system suppliers are given black box specifications, and second-tier sub-contractors are given detail controlled ones. Triangulation, i.e., a relationship model where innovative expert suppliers participate directly in integrated development even though their components are delivered to a system supplier, might become an increasingly important alternative (Figure 5-5).

[90] The governance mechanisms are used to regulate the buyer supplier relationship and thus, ensure that the specifications are realised. These governance mechanisms can be made part of a contract so that the validation takes place continuously rather than intermittently. This makes the role of contracts even more important as a validation mechanism.

[91] This thesis will not explore whether the black box suppliers are partner/mature/child/contractual in nature as it is beyond the scope of this thesis.

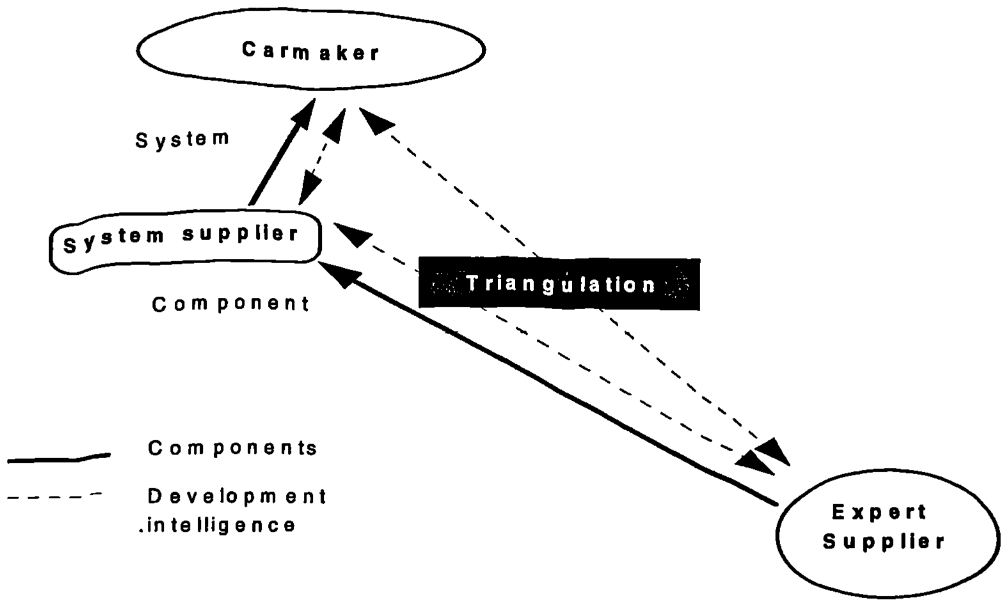

Figure 5-5, Triangulation (adapted from Lamming, 1993, p187)

In this model, three actors will be directly involved in the specifications. This emphasises the need for precisely defining the roles of one another.

- **Technical Content**

Once the role of the supplier has been established, the content of the specification deserves to be clearly mentioned. If the supplier is a detailed parts supplier, then the completeness of the specification in all respects is a necessity. In the case of a black box supplier, the specifications may be written in such a way that they will be able to manoeuvre and use their engineering capabilities. In order to reduce the problems concerning the level of details in requirements, clearer information from the OEM may be asked for. Black box engineering necessarily redefines the role of the specification. The data indicates that the specifications can become more interactive than traditionally was the case. Faced with an ambiguous situation, suppliers may find it necessary to become more proactive in their customer relationships in order to obtain the information they need to do their work correctly. Moreover, the experience of Product Development Managers was that the more active the supplier was in searching for information on his own initiative, the greater were the chances of profiling the company as an expert supplier. If specifications were used for spontaneous discussions with the suppliers for example, through Lotus notes/EDI, etc., many of the content related problems could be avoided.

The internal performance of the supplier company in terms of information transmission and a relevant understanding of transmitted information will also be informally assessed in black box engineering.

- **Changes**

The studies in the OEM show that the product specifications, as defined by the OEM's product development staff, are already the result of a very large number of interactions and adjustments. Before involving suppliers, it is desirable that the OEM makes sure that all internal functions agree on the specification outline and that no contradictory messages are emitted from different functions to different suppliers (or even to one and the same supplier!).

For particular components there could be a core specification valid for all OEMs[92] in the same business. The core specifications may be the same for all the OEMs with only specific features or distinguishing characteristics specific to the OEMs.

There can be sequential freezing every time partial specifications of a component or system have been mutually agreed upon between the OEM and all interfacing suppliers. This would oblige comprehensive testing of prototypes and updating of specifications allowing all actors to advance on the same line. At the supplier level, suppliers may be obliged to put in more development resources and develop a more flexible development organisation with strong links to manufacturing. They may also need to have flexible schedules for design technicians, open space design departments allowing for intra-functional exchange of knowledge and information, and to take initiatives for direct contacts with operational design staff in customer firms to reduce information gaps.

[92] In other words, there will be one common specification for a certain component, such as a brake cylinder, for all the automotive OEMs.

In order to balance the trade-off between the perpetual change of specifications during the development process and the demand for short development lead-time, it might be useful to divide the design process into two parts:

- The functional concept. This is the product technology that will solve the functional problem that the customer presents;
- The dimensional definition. This consists of the dimensions and the form of the component.

If suppliers learn to work with "sets" of functional concepts in a first phase and only subsequently devote time to the dimensional definition (after intensive exchange of information with customers and interfacing suppliers concerning the functional concepts), they would be able to reduce development lead-time and redundant work, and at the same time respond to the evolution of specifications in a flexible manner.

Besides the possibility of freezing hard specifications later, the observed use of the set-based approach followed by Toyota could promote innovation. When working in this way, customers became informed of a broader spectrum of the suppliers design capabilities. This made it possible for the supplier to further interest them in the possibility of proposing solutions that went beyond the perfection of single component performance - for example, mini systems or different technology for resolving a specific functional problem. These observations confirmed a somewhat contradictory practice compared to the general perception of "lean" product development. Suppliers were indeed involved early in the development process, but hard specifications tend to be fixed as late as possible to promote innovative solutions. Thus, instead of talking about early design involvement, the case studies suggest a permanent design involvement and a late component procurement for successful black box projects.

- **Cost**

In order to balance the trade-off between technical/marketing requirements and cost targets, a good project integration in the OEMs can be developed. The level of specifications needs to relate not only to the market need, but also to whether the customer is willing to pay for it or not.

The cost of components can be openly discussed with black box suppliers before fixing framing specifications. If the supplier were involved from the beginning in the cost discussions then the estimates would be more realistic as the supplier would include the possible number of change loops in his cost estimates. Changes are a part of the specifications and if the supplier understands this, it can lead to the specifications being used as a tool to discuss the forthcoming product. Finally, the cost parameters may also be clearly stated in framing specifications to avoid "free" interpretations that tend to promote more expensive materials and other types of over-designs making costs increase.

- **Participation**

In projects that meet and exceed the set goals (price, service, technology and service), the specification was found to be not only a support structure for the technical problem solving at an individual level, but a vehicle for inter-functional and inter-company collaboration. As such, it improved co-ordination in different interfaces and creativity in product technology through the exploration of several different ways of resolving problems.

A specific communication mode, which I label "permanently open communication channels", was found (from the data collected) to provide the essential amount of interaction needed for smooth joint specifications. Its properties can be summarised as:

- High frequency of information exchange
- Non project-tied information exchange
- Non sequence-tied information exchange
- Openness and frankness; problems are discussed in order to find solutions together and there is a margin of negotiation within the triangle of quality, cost, and lead time

The above discussion emphasises the possible advantages if managerial focus can be on supporting the systemic nature of design work and simultaneously avoiding a too scientific way of managing product development. This by favouring a mode that sets creativity free and supports the natural working practices in product development of co-ordination, integration and learning between different participants and functions. It is through systemic work that core capabilities take form, product technology evolves, and inter-firm and intra-firm learning are connected. At the same time, the negative side of systemic work, namely that everyone tends to be preoccupied with anything at any time, can be recognised and mastered.

- **Governance and Artifacts**

The factors that govern the relationship, identified from within the OEM, can be described as control, limitations and prototypes. Authors like Bowen et al. (1994) treat prototypes as a form of understanding mechanism. In line with the same logic, the factor *understanding* will be treated under prototypes. If suppliers are clearly defined from the beginning, then control can be exercised accordingly. If the number of prototypes and the reasons behind the prototypes are defined from the beginning, the need for prototypes would be understood. A clear understanding from the beginning enables a joint decision regarding the limitations and the areas of trade-offs. The suppliers and the OEM can better understand each other if the suppliers are encouraged to ask questions and the OEMs encouraged to give information as and when necessary.

- **Control**

There is a move by the OEM to increase the dependency on suppliers and thus encourage the suppliers to contribute more. However, if all the design work is given to suppliers, then no internal engineering knowledge will be left within the company in several technology fields. With every proposal for a new demand, the OEM will be forced to run to its suppliers and thus will be over dependent on them. To limit this problem, OEMs write the top or overall level specifications for functional systems and conserve the overall engineering capability within the production chain. However, currently the case study OEM not only writes the system specifications, but also defines demands on the specifications of detailed components. That being the domain of the system suppliers, the move towards increased supplier contribution is true.

The case studies confirmed this move, but there was confusion as to what a system supplier actually is. Certain suppliers call themselves system suppliers, yet they are given component level specifications and are not allowed to work on grey or black box specifications for the components to be incorporated in the system. Even if they are allowed to work on the system level specifications, their input is hindered to a very large extent. An obvious reason for the confusion met in supplier firms concerning the level of details in specification was thus that the suppliers' role was often far from clear within the OEM.

- **Limitations and trade-offs.**

The limitations of the specifications may be better understood if the OEM and the supplier work jointly on them. This is desirable so as to confirm that there are no unrealistic demands placed on each other. Limitations in this case signify the limitations of the demands and validation requirements put down on the specifications. I will demonstrate this with an example. Temperature and air speed define comfort in a car. The OEM can develop a comfort specification, which includes the air speed at the window, and at the floor of the car and also the blend curves that are to be satisfied in order to get comfort. This is given to the black box supplier for development. When the curves are received from the suppliers, they could be different, then the suppliers and the OEM can jointly work on the limitations and the trade-offs in the specifications.

In many instances, the suppliers do not read their specifications or understand them, for example, the fact that the curves depend on the market need. Fat people require a faster cool down and hence the blend curves will be different for fat people than for thin people. This provides an ideal opportunity to understand the limitations in the specifications and then appropriately make the trade-offs. There may be a tendency to hide problems and not correct problems at an early stage. The problems are sometimes not foreseen, hidden to protect people, etc. The understanding of the limitations can help to reduce the problems to a great extent, i.e., by making unrealistic demands and expectations void.

- **Prototypes**

OEMs need to find ways of validating what they ask for. These validation requirements can be made clear through the validation of specifications. A clear understanding of the needs for the different types of prototypes may prove beneficial, as all prototypes need not be complete in all respects. If this is not taken care of, costs may increase. An understanding of the relationship between the test periods and cost may prove to be critical. The more delayed a test procedure, the more will be the incurred cost due to different reasons such as tooling costs, etc. There is a clear need for the different participants in the specification process to read and validate the requirement flow-down. Seminars between the buyer and the supplier may be a useful method in order to reduce the ambiguities and improve understanding. They help the co-ordination and are an open arena for co-operation.

5.5 Visions for Suppliers[93]

In order to analyse the creation of common visions between the suppliers and the OEM I firstly, examined the presence and perceptions of visions in the auto OEM. The corporate vision was explicitly stated as

"Proud staff winning through excited customers"

I looked for project visions and product concepts as articulated by Bowen et al (1994) and did not observe any. The auto OEM simply did not have any project visions and product concepts. Since I am probing a single platform, which can have many product concepts as the number of platform variants, I will not discuss product concepts and instead limit the discussion to the project visions. Further interviews demonstrated that the corporate vision was just too subjective to be broken up into project visions. Some reasons that ratified the subjectivity are as follows:

- Engineers in the OEM interpreted customer enchantment to developing as many new systems in the car as possible. The OEM thus had to deal with too many new systems that had validation problems leading to project delays and customer disenchantment.
- The above problem was further complicated as it was difficult to understand the customer exciters and what being proud meant to the staff. For example, many of the purchasing staff behaved arrogantly with the suppliers.
- The vision had no indication as to how to deal with suppliers.
- Excited customers would mean offering all features that the customer needs and desires. But that is not possible as it involves a number of trade offs. For example while marketing may want all the features, engineering may not be able to fulfil it as they do not have the technology, have problems with validation requirements, etc.

[93] This paper is forthcoming: R. Nellore, (2000), Visionary Driven Outsourced Product Development, Journal of Supply Chain Management.

In any event, I asked the project staff as to the visions that guided their project work given the fact that the existing vision was difficult to work with. I sent out 400 questionnaires to people internally in the OEM involved in the development project in order to identify what they considered as project visions. It is to be noted that many respondents indicated more than one project vision. The result is presented in Table 5-7.

• Unique combination of performance handling and comfort with high quality standards	54%
• To do changes that one can trust	54%
• Premium quality, reliability, fun to drive	53%
• Stand apart from the crowd	45%
• To make the best possible quality	43%
• Qualify as a member of the premium segment	33%
• Performance, individuality	33%
• To give the customer a degree of satisfaction, thus giving the OEM good business	30%
• Trouble free ownership, value for money	26%
• To generate better financial figures for the company	16%
• To secure position in the premium market	10%
• Lower costs than competitors	10%

Table 5-7, Employee defined project guiding visions (those that scored at least 10%)

Careful examination of Table 5-7 shows that the visions for the relationships with suppliers are not evident amongst the project staff even though outsourced product development was being engaged in. The vision for dealing with suppliers[94] was not seen as important by the project staff as was the case with the corporate staff who created the corporate vision. One could hypothesise that the visions exist to guide the internal management and not external management (such as managing suppliers).

[94] Visions for suppliers are intended to guide the internal OEM employees on how to deal with and manage suppliers of different capabilities and capacities.

5.5.1 Effects of visions for suppliers on outsourced development

I will explore the effects of visions on outsourced product development between buyers and suppliers through an example. There are three forms of integrated audio systems that are offered by the OEM to the final customers, which are in turn sourced from an audio system supplier.

- The radio
- The radio along with a cassette player
- The radio along with a cassette player and a Compact disc player (CD player with place for one CD).

During validation testing alternator noise was observed which was audible whenever the cassette player was switched on. The OEM engineers thought that it might be a problem with the audio system, but later discovered that it was a problem with the wire harnesses. There were a lot of wire harnesses (supplied by the wire harness supplier) above the radio, which caused magnetic interference when the cassette player was switched on. The problem was not discovered in the early prototypes, but later in the pilot series with just two weeks left for building customer cars.

At a first glance this problem might seem to relate only to the assemblers way of integrating the system, but it was in fact more complicated than that and directly related to visions. Due to different equipment levels and options, the wire harnesses are unique for almost each car. In order to understand the problem, the specifications for the audio system was looked into. The following issues were observed:

- No statements linking the interconnection between the audio system and the wire harnesses were found. In fact, for minimal magnetic interference there should be as few wires as possible above the radio.
- The operating environment was not described in the specification and the OEM could not sue the supplier as the supplier had done exactly what had been specified.
- It was mentioned that the audio system should operate under ambient environment and ambient noise. But the specifications did not mention what ambient was.

- It was also not mentioned what would happen if the problems were not solved, i.e. what were the responsibilities of the OEM and the supplier respectively.

The problem was observed to be related to the positioning of the supplier in the wrong category. The supplier required detailed specifications and was in fact given open specifications. In other words, the lack of visions for suppliers allowed the wrong positioning of the audio system supplier. To overcome the problem with the alternator noise there were a number of options as illustrated in Figure 5-6[95].

[95] This figure displays the different solutions that can be used but does not recommend any particular alternative/solution.

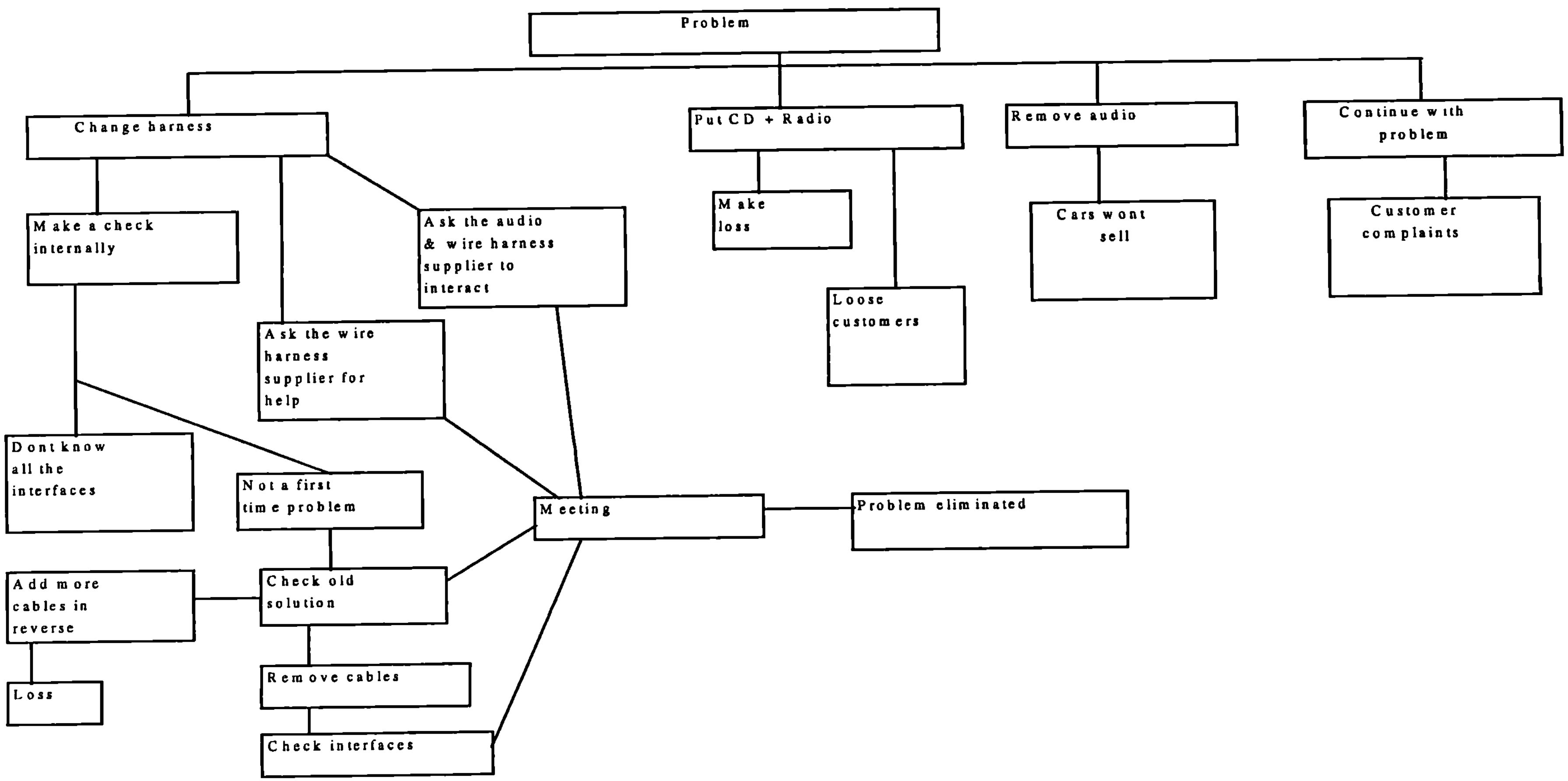

Figure5-6, Solution Schemes for solving alternator noise problem in the car

The employees did not know what option to undertake. There was no vision to guide the people and thus the project about dealing with the supplier/s. As the OEM wanted to keep control over the integration, they did not want the wire harness supplier and the audio system supplier to collaborate, which further complicated the problem. The alternator noise - wire harness problem indicated the following:

- There is a clear need for identifying the type of supplier and developing visions of dealing with the different types of suppliers.
- The supplier may be required to look into the environment when deciding on the product.

Examining the factors closely it becomes apparent that visions have to be developed for the suppliers. The second criterion, looking into the environment, is very product specific and is an outcome of well-defined visions i.e. either the buyer or the supplier will be able to take the responsibility depending upon the partition of the work. I will now examine how to develop and sustain the visions.

5.5.2 Creation of visions for suppliers

Past observations with other companies allow us to corroborate Lipton's (1996) statement that visions are the sum of the mission, strategy and culture of the company. Creation of visions for suppliers would need to encompass them as well. I would like to clarify that it would be impossible to create visions for individual suppliers but rather feasible to create visions for supplier categories. All suppliers can be categorised into four distinct categories (Kamath & Liker, 1994) namely, partner suppliers, mature suppliers, child suppliers and contractual suppliers.

In developing the visions for suppliers, the joint mission will be considered at first. Discussion of the OEM mission or strategy or culture alone will not be of interest to the suppliers'. Thus, the mission, strategy and culture will have to be discussed at two levels; at the OEM, and at the supplier. Then a match will have to be created. This matching process leads to the interim position (Figure 5-7) or in other words creates the ground for developing the vision.

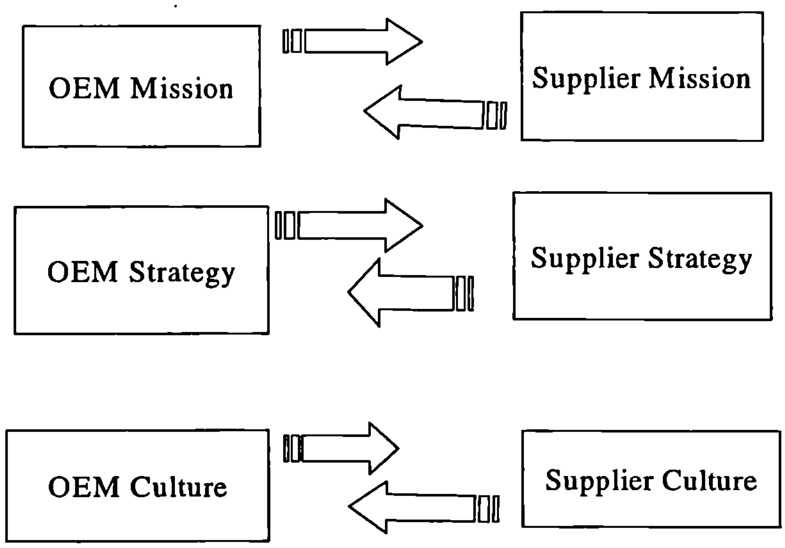

Figure 5-7, Interim Condition

After the interim condition is reached the real task of developing the vision begins. The concept of the interim condition further needs to be developed further. I will assume that the mission of the OEM is to sell at a premium price and thus sell a high quality car. The mission of the supplier on the other hand can be to sell to volume producers with "acceptable" quality. Now, when these diverse views are reconciled the joint mission could be to deliver a premium car to the customer with high quality components and with maximum profitability in the value chain.

I will now consider the strategy part of the interim condition. The OEM strategy in order to achieve its mission could be to have differentiated products whereas the supplier strategy could be cost leadership. Reconciling the differences, the common strategy to achieve the joint mission could be to focus on high performance and quality and thus, focus on a particular market segment. Inadvertently, the customer base also becomes clear to the supplier.

In the case of culture, I will assume that it consists of the organisational design elements namely tasks, people, structure, rewards, information and decision making (Hanna, 1988). Comparing the two cultures at the suppliers and the buyers will offer a dearth of information regarding compatibility. The elements can be reconciled, for example, proud people who think that the "OEM is always right" can be removed from the project.

The interim condition leads to the creation of the vision for suppliers. The joint mission is related to "What do we want the supplier to do?", the joint strategy is related to "How will the supplier execute the task and what will be the OEM contribution?", and the culture issues are related to "What are the characteristics of the supplier?", "When will the supplier be involved?","What decisions can the supplier make?", "How and when will information be distributed?", and "What actions will be rewarded?" This is shown in the Table 5-8 below. This leads to the creation of the visions for the different types of suppliers.

Category of Supplier	Constituents of the vision for suppliers
Partner Mature Child Contractual	What do we want the supplier to do? How will the supplier execute the task and what will be the OEM contribution? What are the characteristics of the supplier? When will the supplier be involved? What decisions can the supplier make How and when will information be distributed? What actions will be rewarded?

Table 5-8, Creation of Visions for suppliers

The vision statement for the suppliers holds the line of business guiding vision, the product concept and the project vision in unison and allows the specification to be generated according to the capabilities of either the supplier or the OEM or both with varying degrees of involvement (Figure 5-8).

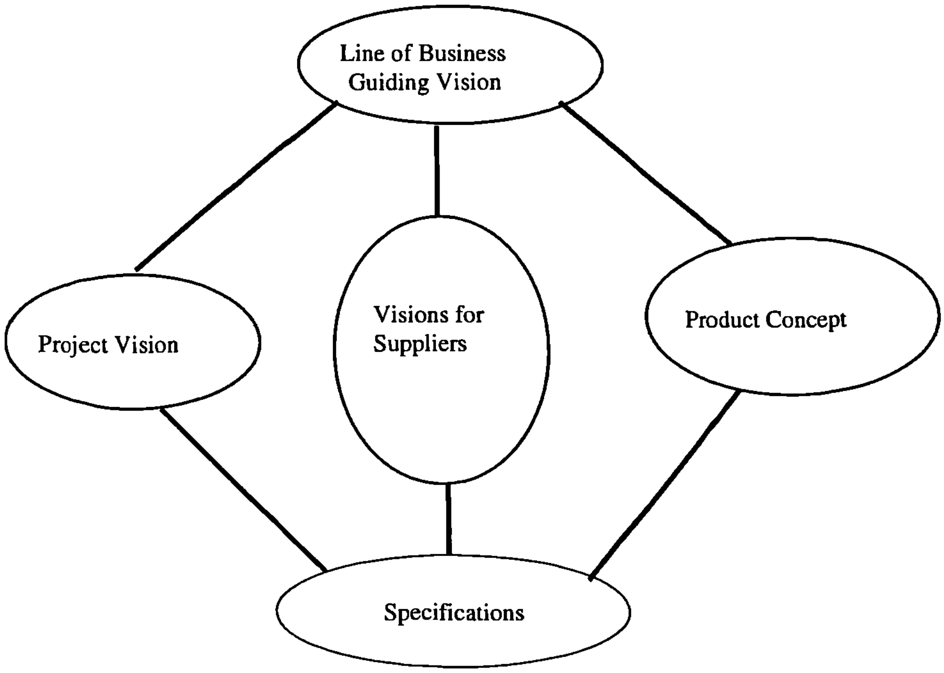

Figure 5-8, The vision for suppliers

5.5.3 Deployment of visions

New guiding visions will need to be constantly developed in order to cope with the dynamics of the competitive and technological environment. In the OEM, our study incited engineering management to think about the development of appropriate and more detailed project visions. Besides the question of how to articulate visions corresponding to these different objectives, the question of how to deploy them and make them accepted therefore preoccupied managers. An understanding of the process of deploying guiding visions could be developed by looking at a further example.

A supplier had recently incorporated a distinct project guiding vision[96] as follows:

'Reduce the global cost of a component solution through innovative functional solutions'.

[96] Data was collected jointly with Soderquist, K., (1997), *Inside the tier model: product development organisation and strategies in automotive expert supplier firms*, Unpublished Doctoral Thesis: Henley –Brunel, United Kingdom

1. Strategic goals and their reason of being in the company are explicitly communicated to employees. This is done through memoranda, notes, information meetings on the part of general management, training, etc. When involving suppliers' the reason for being must be extensively communicated and in particular the relation between the work being engaged in and the supplier categories.
2. The top-down information diffusion approach may be complemented by a bottom-up return of information where management ensures a comprehensive analysis of operational situations based on feedback from employees. This can help to merge the strategic and operational decisions and thus increase the effectiveness of the suppliers involvement.
3. A key to successful deployment of guiding visions is the ability of management to prove the seriousness of communicated guiding visions through concrete interventions in the organisation. For example, the creation of a specific dedicated team with a product champion will materialise the guiding vision of promoting innovative design. This could be extended to the treatment of supplier categories and the values regarding the supplier community at large.
4. Employees nced to be able to observe concrete examples of success generated by means of the guiding vision. There is a need for successful examples in order to change the view of the product development expertise held in a company. These examples will have to be extended to the suppliers as well.

Finally, as guiding visions are developed largely based on customers' expectations, it is important to ask *how* driving forces from customers are received and *who* receives them. In order to develop guiding visions that are coherent with the customers' expectations, relevant feed-back of the information collected at all levels may be required to reach the designers of the guiding visions. This information can consist of direct customer input, product technology information contained in specifications, mock-ups and internal design databases, and material and process technology scanning. Thus, different support structures such as information systems, and project group meetings also play an important role in deploying guiding visions.

5.5.4 Interplay between visions and core capabilities

I will explore the effects of visions for suppliers on the capabilities to use resources in order to improve the development process. In order to do so, I will use the core capability framework developed by Bowen et al (1994). The framework consists of knowledge, managerial systems, physical systems, and values. I will use the example of the relationship between the OEM and a global seat supplier over the project period.

Towards the end of development, just before delivery of customer cars, problems were noticed in the seats. They were uncomfortable. In accordance with the supplier typology of Kamath & Liker (1994), the seat supplier qualified as a mature supplier. However, it was considered to be a partner supplier by other OEMs as it had an enormous capacity to innovate with numerous product concepts under development. The OEM considered itself to be the best in comfort and thus felt it necessary to give detailed specifications to the supplier. The values in the OEM reflect that it is the best in the industry. This value encouraged the OEM to forget that the supplier, by virtue of working with many different customers, had developed the latest state-of-the-art test methods. Moreover, a narrow perception within the OEM's engineering department concerning learning opportunities from suppliers lead to the OEM's dictating a slightly outdated test method to the supplier. The visions influencing the current state of capabilities in the buyer-supplier interface are displayed in Table 5-9.

Dimensions of core capabilities	Current State of the capabilities within the auto OEM
Knowledge	Comfort knowledge (like ergonomics) is assumed to be the best practice within the OEM. Therefore, the supplier needs to be dictated comfort specifications, although the seat can be outsourced. It does not matter that the supplier makes interior systems (including seats) for several major global automotive manufacturers.
Managerial systems	Continuous education is not encouraged within the OEM and the incentive system is poor. There are no apprentice programmes. Narrow outlook of staff at the OEM leads to control over minor details. The suppliers' managerial systems are good as they have employed personnel with extensive educational and operational backgrounds and in fact many of the auto OEM engineers.
Physical systems	Auto OEM feels that the thousands of hours that have been invested in the development of validation systems is good enough. This perspective does not allow the auto OEM engineers to proactively search for the latest in validation methods for comfort within the supplier base. This is in spite of the fact that the suppliers are familiar with the latest in validation systems in the automotive industry.
Values	The "OEM is always right", and a "We know everything" culture exists within the OEM. Product engineering is the dominant discipline and all the top jobs are offered to engineers. For example, the latest person to head a platform has an engineering background. Engineers hold a majority of the top management jobs.

Table 5-9, Current State of Capabilities[97]

The current state of capabilities led to a future state of capabilities where the empowered people in the OEM did not want to listen to the supplier. In fact, the latest test methods were not even used, as the OEM was not aware of them. The managerial systems in the OEM were not good, for example non technical employees (like process owners) were often frustrated and afraid of losing their jobs. This meant that they tried to control minor details in the process of managing suppliers. Due to a fuzzy vision of how to integrate development with suppliers, the knowledge sought from the supplier was very limited; the OEM did not take into account the fact that the supplier had a world-class expertise in seating.

[97] Dimensions adapted from Bowen et al (1994); Grant (1991); Stern (1992)

The future state of capabilities as a result of the dysfunctions identified above is presented in Table 5-10.

Dimensions of core capabilities	**Future state of capabilities within the auto OEM (without remedial action)**
Knowledge	Supplier input is not taken into account and multiple concepts are not encouraged and tested. This will lead to a slack in seating technology.
Managerial systems	Non technical jobs are not encouraged. Faulty appraisals and empowerment systems can lead to loss of skilled employees and extremely costly power struggles.
Physical systems	The lack of technology scanning through suppliers will lead to outdated testing systems.
Values	The empowered people in the OEM do not want to listen to suppliers, thereby, reducing supplier credibility further. This leads to technical isolation in an engineering ivory tower.

Table 5-10, Future state of capabilities with the continuing negative trend[98]

The above case demonstrates a number of critical factors, which are listed as follows:

- The values in the OEM were affected by the visions they had for the suppliers. Unclear visions as to how to deal with suppliers led to insufficient attention being paid to the suppliers.
- The values affected the physical systems dimensions. The "we know everything" culture biased the OEM into not taking advantage of the physical systems of the supplier and instead relying on its internal outdated systems.
- The values affected the managerial systems. The managerial systems turned the organisation into chaos where only engineering jobs were encouraged and the uncertainty due to the large number of problems in the final product led to their concentrating on petty details.
- The value dimension affected the knowledge sought. The OEM staff with their engineering drive always felt that the suppliers did not know anything, which led to unnecessary problems and changes during the development of the product.

[98] This was the state that was reached by the auto OEM as observed during this longitudinal study.

The existence of visions for suppliers can help build the development of good values like faith in each other's abilities, trust, social responsibility towards the employees, and team working depending upon the category of the supplier. Good physical systems can develop with the emergence of comprehensive data systems, exchange of data, world-wide project management systems, and technology sharing between customers and suppliers in view of improving technology synergy. Good managerial systems can be developed by the emergence of comprehensive training and development programs, or programs to improve motivation. The knowledge aspect can be improved by understanding the capabilities of different actors and by developing broad-based inter-functional and inter-company values in project teams. There needs to be a clear match between the four dimensions of core capabilities between the buyer and the supplier. If the visions for suppliers are not clear, i.e., if the place and role of each actor, and the expectations based on a comprehensive understanding of the needs and capacities of one another are fuzzy, there will be problems of over- and under-management of suppliers.

I will take another example to demonstrate the importance of visions. There can be different types of projects in an organisation (Aoshima, 1993). There can be a totally new design, a rapid transfer of functional solutions from other related projects so that there is joint development between projects, sequential design transfer where designs are transferred from unrelated completed projects, and lastly design modifications within a specific project. The auto OEM tried to implement a sequential design transfer from an unrelated completed project in terms of carrying over the radio, cassette and CD player from one of its subsidiaries. In order to fix the carry-over in the new model, auto OEM had to change the illumination intensity in the display panels to ensure that it matched with the SID (Side Instrument Display). After the project was started, there were a good number of delays:

- Two different suppliers supplied the tape tuner combination and the CD changer. None of them matched the bus (signal carrier) protocol of the auto OEM.
- During project start up, the tape tuner supplier got a major order from one of the leading volume competitors and so did not spend much time in solving the bus

protocol with the CD changer supplier. The subsidiary, however, continued to buy the same tape tuner as it matched with its bus protocol.

- During this time, the styling department and the marketing department at auto OEM realised that the styling of the audio system would not suit the interior design. The styling department was contemplating whether or not to change the appearance on the front of the tape tuner. This new front alone would have cost millions of dollars. There was a year of activity after which the project was scrapped. Hence overall there was wastage of time, cost, and resources.

The example demonstrates that the audio system supplier was assumed to be a partner supplier and expected to take care of the interfaces. Yet he was not, as he was a mature supplier. The level of knowledge in the specification writing was misunderstood. The managerial systems in the relationship were not tuned to improving the relationship. For example, the OEM did not work on incentives to be exchanged, work on the bus interface, etc. This meant that the OEM did not emphasise that the bus solving capabilities were the most important in the relationship. The physical systems did not encourage the relationship. There were no facilitating factors for communication such as a common information system. The values were problematic in this case as the visions for the product was not tuned to solving the problems. The problem motivates the need to carefully match the visions and the capabilities.

In conclusion one can observe that the vision affect the culture of the company which in turn affects the knowledge that the company seeks and wishes to retain. This has an effect on the managerial systems and the physical systems as well.

Non identification of visions for suppliers was observed to be a factor negatively affecting the final product. Undoubtedly due to their smaller and less complex organisations, the suppliers had a much clearer vision structure than the OEM, with well linked corporate and project visions. Deployment of visions was also identified as a crucial factor. It was observed that the complexity of problems that may arise by not understanding the impact of different levels of guiding visions and the differences between the different types of suppliers. The analysis indicated that in order to obtain a viable product, a complex web of interconnected factors might be considered. The most important implications from this thesis could be described with reference to the following model (Figure 5-9) which essentially captures the conclusion.

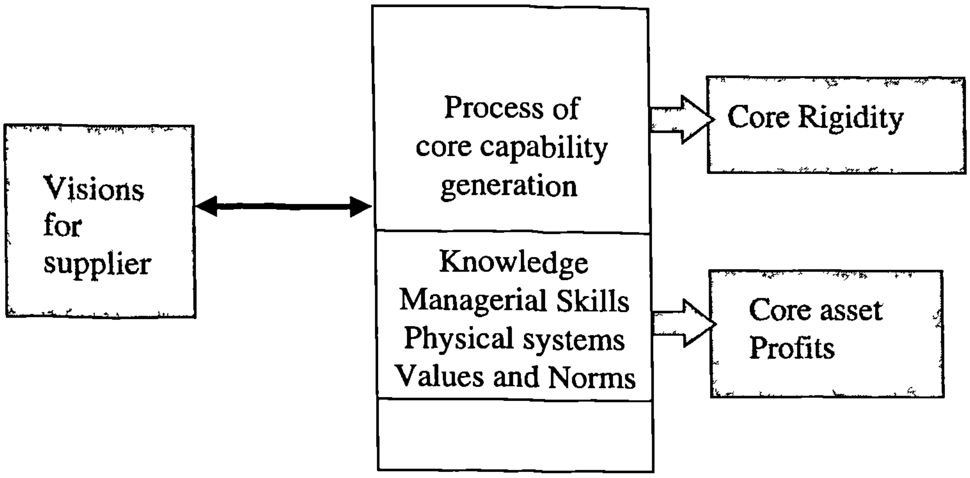

Figure 5-9, Integrated means of guidance related capability generation model (Source: author)

Visions for suppliers playing a guiding role affect the core capabilities of an organisation, for example, as analysed in our case study, the relationship with suppliers. The output can either lead to a core rigidity/bad product or a core asset/viable product. Hence, in order to get a viable product the link between core capabilities and visions may be taken into consideration. Fuzzy visions could spell trouble for companies. In the case of the seat supplier, the state of capabilities was heading towards a core rigidity in terms of designing and testing seating in-house using outdated techniques. With an appropriate vision guiding the relationship, considering the supplier as a partner supplier, and emphasising learning opportunities, the state of capabilities could lead to a core competence in integrated design of seats based on technology and competence-sharing and synergies.

5.6 The specification model

I will now examine the final research question, namely that on the model of specification. The limitations in the existing models of specifications to link the OEMs with the suppliers necessitates the development of a model that allows the suppliers to be visible in the OEMs specification process. There is only one version of specifications in the auto OEM. However, it appears that OEMs can do much more than the customers want. Hence, there is a need to separate the two, so that futuristic products can be created for tomorrow in today's development. For example, the product specification can be used internally within the OEM to develop the product, whereas the customer specification can be utilised by the customers to verify the product. The ability to develop internally achievable specifications (compliance cards) that are different from what the customer expects (customer specification) allows internal talent to grow and make the organisation a stimulating place to work. It allows the organisation to be one step ahead of its competitors. In order to create a knowledge bank within the company, there is a need to have the datum requirements, which are already verified requirements from previous projects. This will allow the various people to be co-ordinated as is necessary in development, according to Karlson (1994). It also allows the distribution of information, which, according to Nonaka (1991), is a critical success factor in Japanese companies. Also, this allows the demands to be articulated and not forgotten. As too often, demands that cannot be achieved are forgotten, thus leading to the product being different from what was originally planned.

If the original demands are not forgotten, then they could be introduced as running changes as when the technology permits their introduction. Compliance cards where each and every requirement is put on a card, can be utilised. The compliance cards are decomposed step by step and thus allow the engineers to remember the requirements to be fulfilled. Computerisation of these cards would allow easy retrieval and follow up. The requirements are simulated in the auto OEM through the validation loops, i.e., each level of the specification namely the VTS, SSTS and CTS has a corresponding validation plan, namely, VVP (Vehicle validation plan), SSVP (sub-system validation plan) and CVP (Component validation plan). The generation of the specifications and the decomposition of the specifications, as corroborates Fine

& Whitney (1996), allow a pattern of divergence and convergence to emerge, i.e., information is collected, analysed, synthesised and new information collected again when necessary. This confirms the convergence divergence propositions of Kaulio (1996). In auto OEM, the supplier uses the CTS/SSTS to generate or produce the product and validates it through various test methods. The OEM in turn validates the product through its own validations such as in prototyping and then decides the condition of the product. The different types of specifications confirm the propositions of Kaulio (1996) that they change over time, and on the other hand, it also confirms the propositions of Smith & Reinartsen (1991) that the specification is a document created by the joint labour of the different people involved in the specification process. However, what was not mentioned by either Smith & Reinartsen (1991) or Kaulio (1996) is that the different types of specifications are related to each other and there is a step by step decomposition of the specifications from a higher to a lower level, i.e., the MSS to the VTS to the SSTS and to the CTS. The VTS and some of the SSTS and CTS cannot be created from scratch within platform variants as they share common components and processes. Therefore, all platform variants have to start with a common VTS and can change the SSTS and the CTS from the common platform template through a work order.

5.6.1 Model of product development by specifications[99]

An attempt will be made to create a specification model as a result of the study in auto OEM. The market segment specification is created at first (Figure 5-10). The input to the market segment specification will come from the previously verified requirements (PVR), market trends, own brand requirements, competitors, voice of the customer, suppliers, voice of the distributor and the legal demands. While elaborating the MSS, the inputs are continuously monitored and feedback is given from the MSS while it is taking shape.

[99] Portions of this section have been published in the European Journal of Management. See Nellore, R. & Soderquist, K. & Eriksson, K. A., (1999)., A Specification Model for Product Development, *European Management Journal* Vol.17, No.1, 50-63,

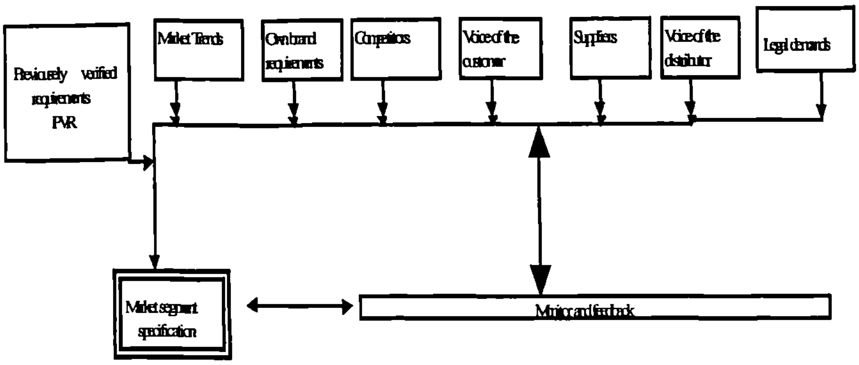

Figure 5-10, Elaboration of the MSS (source:author)

The creation of the Market Segment Specification leads to either advanced development or to platform based development. Advanced development is not time based and develops technologies that can be used by the different platforms while platform based development is concentrated on all the technologies going to a single platform. In effect, advanced development captures fast clock speed technologies as proposed by Fine (1998) and then releases them to the platforms as appropriate. The output of the advanced development phase is an input to the VTS. The advanced development phase commences by developing proposals for advanced work. Among numerous proposals that are developed the most promising ones are selected and prioritised for further development. Depending upon the resources available with the company the proposals can be developed to a working prototype stage or simply left at the idea stage with a detailed analysis. Both these outcomes form inputs to the VTS as the platforms can choose to either implement the working prototypes into their development or develop the ideas for implementation. The technologies form add-ons to the existing generic VTS for the platform. Figure 5-11 illustrates the advanced development process.

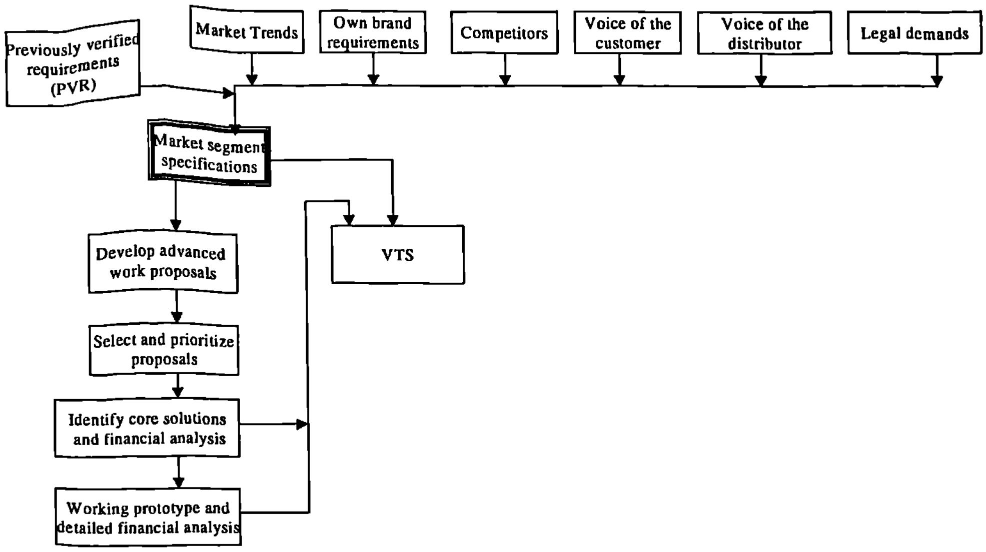

Figure 5-11, Advanced Development process (source: author)

The work on the VTS commences once the market segment specifications have been created. It is split up into the customer specification and the compliance cards (internal product specification), as the internal company goals may be higher than what the customer expects. These compliance cards are used to generate the SSTS and in turn the CTS. Each compliance card is a requirement and all the requirements in the VTS may have to be identified. The compliance cards may have references to drawings and could contain the details of the other compliance cards that they are interfaced with. The compliance cards could contain references to the SSTS and the CTS. In fact, if all the compliance cards are computerised, then at the simple touch of a button all the requirements, interfaces and all the system level requirements to the component level requirements will be available instantly. It would then be very easy to validate whether all the requirements have been fulfilled or not. Figure 5-12 illustrates the generation of these different levels of specifications.

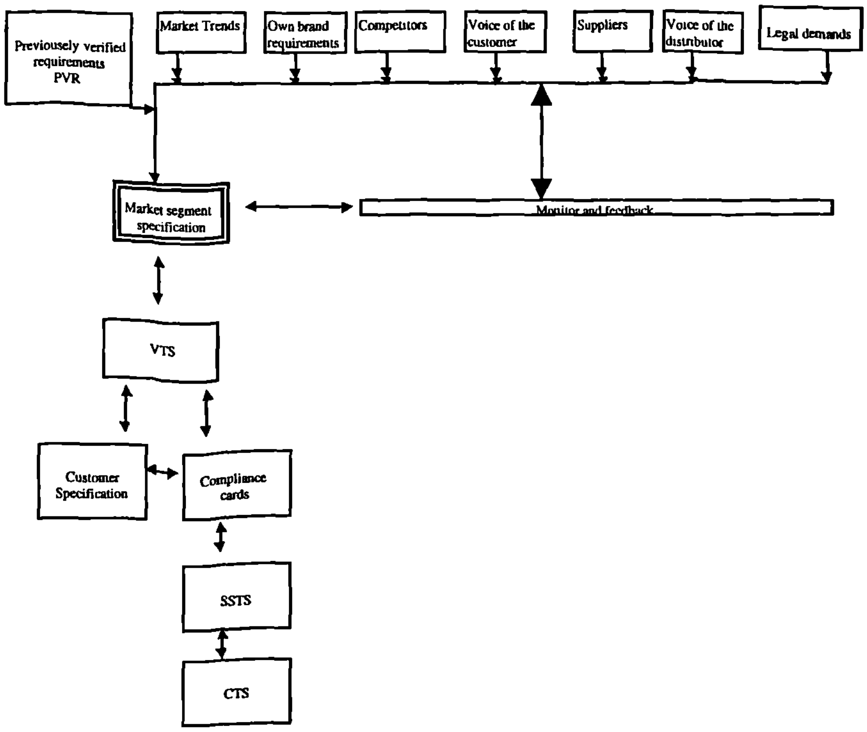

Figure 5-12, Generation of the Specifications (source: author)

Validation plans are generated next. The Component validation plan (CVP) is generated from the CTS. The SSTS is used to generate the SSVP (sub-system validation plan) and lastly the VVP (vehicle validation plan) is generated from the VTS. In case of problems during validations, problem tracking is undertaken and the input fed to the necessary stage in the specification process (Figure 5-13).

The car is a compromise and not all problems that arise during the building of the car can be solved or need to be solved. For example, there are many problems that the customers cannot notice, for example, the tick – tack sequence in the indicator of car. Hence all the problems need to be collected together and the risk associated with the problems is determined by assigning them priorities such as A, B or C (problem tracking). Then, depending on the priorities, the A problems followed by the B and C problems are sent to either the VTS or the SSTS or the CTS stage. Problems are sent to the VTS level as it may be hard to determine where the problem lies in many cases. Again the validation loop is repeated with further problems being sent through the priority analysis stage as well.

Depending on the decision of the core team as to certify the VTS to be ready for manufacture, the VTS is sent to the manufacturing stage. The manufacturing process might prove that some designs cannot be manufactured and hence these will have to return to the VTS level for inspection and breakdown to the necessary level. This is needed because only the VTS documents have the complete interfaces of the car. Once again the validation loop is repeated. Once the core team has cleared the manufacturing process, customer products can commence to be manufactured.

There needs to be a group of people dealing only with the whole car/product. There are certain requirements that may not fit into any of the sub-systems and hence require the presence of such a group. For example, balancing the overall weight of the car. This group would be the best to deal with issues that arise at the VTS level or those that cannot be sorted out at the CTS/SSTS level.

After the product is manufactured, it is continuously monitored and feedback is provided to the specification process. For example, input is provided to the market segment specification with regards to the customer satisfaction/experience and also to the top level of specifications. All changes and solutions generated are to be written back into the specifications so that the demands are not forgotten and also the fact remains that it can be used as a black book for personnel working on new and continuation projects.

A problem may have its origins in the interfaces. The product can be monitored on a continuous basis so that the MSS is of high quality and usable. The whole project (specifications) can be in the form of headings with a discussion of the pros and cons of each heading and with recommendations for addition or deletion from the specification. Also, the discussion of each heading and its contribution to the product development process will play a major role in reducing conflicts between the buyer and supplier.

The supplier can be involved during the SSTS phase or the CTS phase. Depending on the type of supplier, testing can be undertaken by the supplier, otherwise the OEM will have to do the same. The specification could be written in such a way that the supplier has the power to manoeuvre and the OEM need not control details. All changes in the specification and reasons behind it deserve to be included in the specification so that the same mistakes are not made again and again.

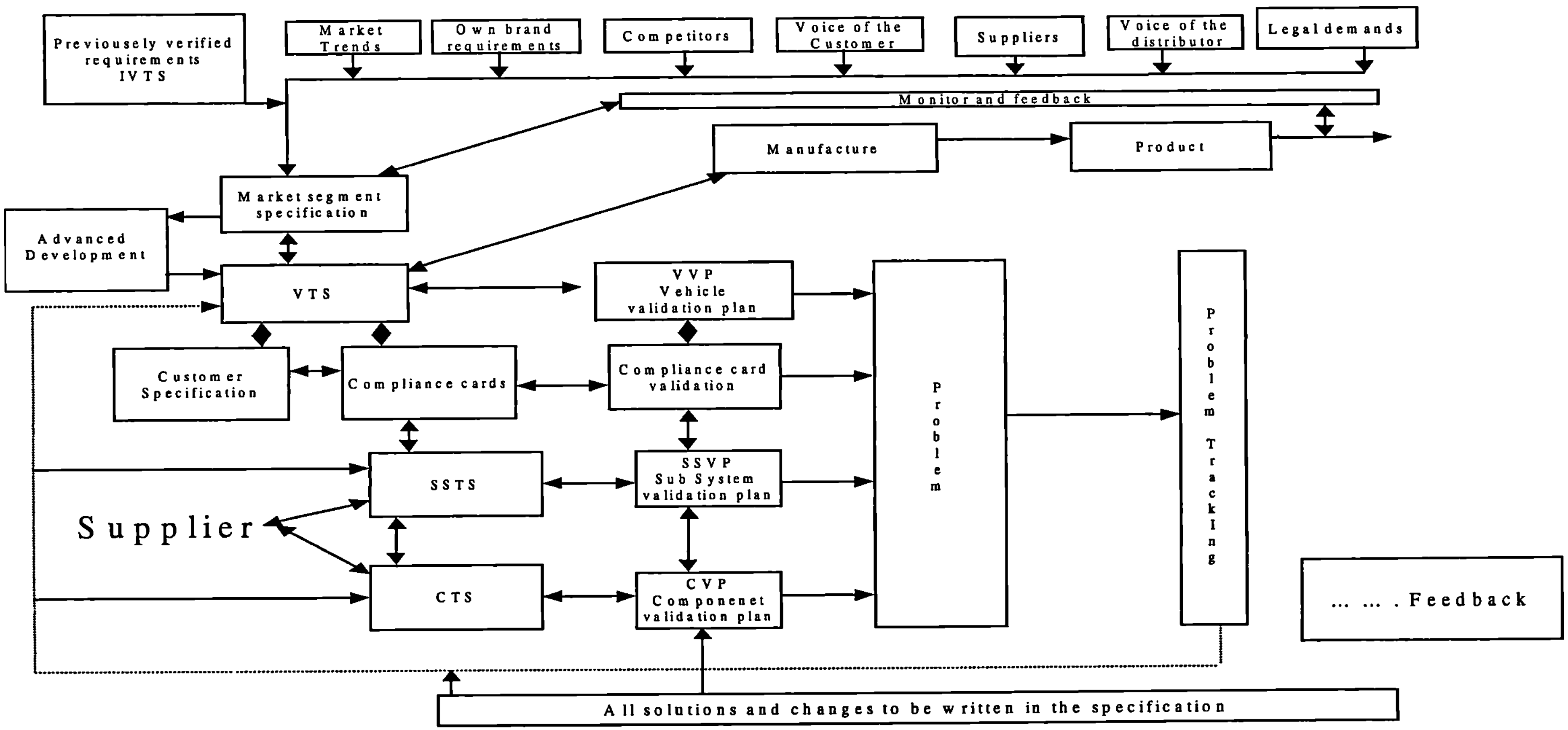

Figure 5-13, The Specification Model

5.7 Conclusion

There were a number of important conclusions reached after the analysis. I will attempt to answer all the detailed research questions and then summarise how the main research question on the roles of specifications can be answered.

The first detailed research question was on the different elements that could be contained in a specification for its articulation. The analysis indicated the eight important elements that could constitute a specification. These eight elements could be fulfilled either by the OEM, the suppliers, or by both in order to converge the understanding of the OEM and the suppliers. The elements identified were customer requirements, functionality, product requirements, process requirements, communications, level of technology, standards and drawings.

The second research question was on the effects of the supplier networks on the role of specifications. The analysis indicated that the suppliers were of different capabilities and capacities and that meant that they required specifications based on their capabilities and capacities. Child suppliers and contractual suppliers needed detailed specifications, partner suppliers created specifications and finally mature suppliers created the specifications after critical[100] specifications were obtained from the OEM. It was identified that specifications needed to consider and understand the capabilities of the suppliers, as the OEM could be dealing with a mature supplier who, in turn, could be dealing with a child supplier. Either the OEM or the mature supplier in this case may have to identify that the child supplier understands the requirements of the final product and incorporates it into the component, etc.

The third detailed research question was on the issues faced with regard to the role of specifications. The analysis of the issues faced in the specifications led to identification of factors that can be followed by the OEM and the suppliers in the management of specifications. The factors that could be considered in the specifications include target setting, content decision of specification, changes in the specification, role of the supplier, need and number of prototypes, and problem tracking. Understanding and validation of the understanding between the OEM and

100 1 Critical specifications are mostly in the interfaces, for example, the length and width of the radio, etc.

the supplier were also identified as important factors. Further analysis of the issues indicated that the specifications were on a continuum from purely narrative to purely quantitative which included a mixture of both narrative and quantitative statements as well. Elements like styling, sound etc. were described in a narrative fashion while components were described in a purely quantitative fashion. Elements like chassis, noise vibration harshness, etc., were described by a mixture of both narrative and quantitative statements. The subjectivity in interpretation and the difficulty of simulating the specifications increased when specifications moved from being purely quantitative to narrative, while the resources required and the level of detail increased when the specifications moved from being narrative to quantitative. The complexity increased when the specifications moved from quantitative to narrative.

The fourth research question concerned the development and deployment of visions for suppliers. It was observed that the creation of visions for suppliers and its successful deployment created a positive impact on outsourced product development. Further, visions for suppliers also impact the core capabilities in the relationship with the suppliers, which in turn affected the final product. Different layers of visions were identified for the different categories of suppliers' as identified by Kamath & Liker (1994).

The fifth detailed research question concerned the development of a specification model in outsourcing development. A model of specifications was generated. Observations from the specification model indicated that specifications could be seen as a means of communication between both internal and external parties, which authors like Clark & Fujimoto (1991), Karlson (1994), Söderquist (1997) have not considered. Throughout the product development process, different types of specifications like the MSS, IVTS, VTS, SSTS, CTS are generated.

The above conclusions can help to answer the main research question on the roles of the specification. If they can indicate roles that the specifications can perform then these can be discussed in depth in the concluding chapter. I will now examine the conclusions to explore the roles that specifications could play.

- The conclusions on the different elements that can be contained in a specification for its articulation could help to improve communication between the OEMs and the suppliers, thus supporting the role of specifications in communication.
- By enhancing the difference between the static and dynamic parts, the specifications could play a role in embedding competitive advantage.
- The conclusions on the effects of supplier networks on the role of specifications could help in differentiating suppliers and then tailoring the specifications to suit the capabilities and capacities of the suppliers. Thus the role of specifications in differentiating suppliers and in deciding the time of involvement of the suppliers could be assisted.
- The conclusion on the issues faced with regard to the role of specifications could help to assist in outsourcing decisions. The knowledge about the narrative, mixture of narrative and qualitative, and qualitative specifications could assist the role of specifications in making decisions on outsourcing.
- The conclusions reached in the specification model could help in communication between the buyer and the supplier and thus facilitate the communication role of specifications.

During the entire discussion above, validation of requirements seemed to be a transversal factor. Without validation of requirements, either the product is not the same as the one that was planned or there could be huge engineering costs in order to get the product right. Given the importance of this transversal factor, it is vital to investigate how the validation of requirements can actually be made possible. In this connection, contracts will be explored in the next chapter. Contracts are being explored as a source of assistance in validation of the specifications.

6. CONTRACTS[101] AND THEIR INFLUENCE ON SPECIFICATIONS

6.1 Introduction

In the theoretical overview (Chapter 2), it was concluded that the importance of contracts[102] (contracts referred to throughout this thesis are written contracts) has been sidelined as far as product development management is concerned. This chapter will analyse the identified parameters from the data collection chapter (4).

6.2 Recalling the identified contract elements

I will recall the different analysis parameters from Chapter 4 (Table 6-1).

[101] This paper has been accepted for publication in the IEEE transactions on Engineering Management. Forthcoming 2001

[102] Contracts are used for validating that the specifications can be satisfied by the suppliers. In chapter 5, terms such as vehicle validation plan, sub system validation plan and component validation plan have been used. These validation plans are for detailed validation of the technical system and thus, could refer to issues that do not concern the suppliers such as in the assembly areas, etc.

ID No	Contract Elements [Main]	Contract Elements [Sub]	Reason for including the Sub Contract Elements
1	Types		
2	Purpose		
3	Responsibility	OEM responsibility, Supplier responsibility, Quality systems.	Responsibility concerns both the supplier and the OEM; what are the responsibilities of each partner and what are the joint responsibilities? A good contract would need to specify this. The quality system that links the OEMs and the suppliers specifies detailed responsibilities both during development and during running delivery and production. I therefore consider that the quality system pertains to the category responsibility.
4	Performance criteria		
5	Legal issues		
6	Communication	Changes	Integrated product development calls for extensive communication [Clark & Fujimoto, 1991]. Söderquist [1997], studying the role of expert suppliers in integrated component development, argues that operational design engineers and technicians invent their own communication modes and channels in an improvised and ad-hoc manner, and that appropriate support structures and guidelines for communication lack. Contracts could help in developing clearer communication paths. How and when design changes are dealt with is, to a large extent, a question of communication [Karlson, 1994]. I therefore consider the contract element changes as pertaining to communication.
7	Payments		
8	Specification – contract link	Testing	How testing of prototypes will be carried out is one of the main elements in a specification [Karlsson et al., 1998]. The contract can help in validating and checking testing procedures. I therefore consider that testing pertains to the specification - contract link.

Table 6-1, Regrouping contract elements

I will now analyse the contract elements one after the other as follows:

6.3 Analysis of the Contract Categories

In this section, the different contract categories as identified from the previous section will be examined in sequence. The first category to be examined will be the versions of contracts.

6.3.1 Types of contracts

As observed, there are many different types of contracts in the auto OEM. The auto OEM contract variants were used at random with the suppliers, so there was no specific rational behind this difference. Rather, it was due to the fact that each contract contained certain elements that the other contracts may or may not contain. This can lead to confusion, especially when the decision regarding the type of contract to be awarded to suppliers is made. This problem can be illustrated with an example. The seats are positioned on rails in the car. The interior department in the OEM handles the seats, whereas the chassis department handles the rails. When different departments are handling different parts of the same system, the system supplier (who is responsible for the complete seat including the rails) could get different and conflicting messages.

The aircraft OEM contract contained supplier-specific parameters connected to individual supplier requirements. Both these variants have advantages and disadvantages as displayed in Table 6-2.

Many Contracts	One Contract
There will be no match between the contract and the capabilities of the supplier if the contract is supplied at random. In other words, the contract will not be able to validate the capability of the supplier to deliver as promised.	A match between the contract and the suppliers' capability to deliver will occur only when the supplier specific parameters related to the supplier types are included in the contract. In other words, contracts cannot have both generic parameters and parameters related to individual supplier requirements but rather specific requirements connected to the different types of supplier categories else the problems of randomness associated with the many contract scenario may be visible.
Problems will occur with multiple contracts especially when different departments are involved in the development/sourcing of a particular system/component.	One contract would mean one message as all the departments would have to caucus to see that their individual needs and requirements are stipulated in the contract.
Generic contract parameters can be forgotten in case there are too many variants of the contract	Generic contract parameters are never forgotten and always present in the contract. In fact as problems arise and solutions are generated they are continuously updated as part of the generic parameters if possible.
There are no visible synergies in the different contracts. For example, it is not clear whether solutions to problems arising from one contract will be put into the other contracts as part of continuous improvement.	It is easy to check problems and put clauses back into all the contracts to prevent them from reoccurring thereby, drawing on synergies.

Table 6-2, Different Contractual Possibilities

The use of a single contract or multiple contracts would depend on the level of detail that the OEM would like to attain in the contracts. A single contract could only contain very generic clauses applicable to all suppliers. On the other hand, there will be little use in having multiple contracts or individualised clauses unless the differences are linked to some rationale, such as different categories of suppliers, as discussed in the literature section. A link to different types of suppliers could help to put clauses into the contract to anticipate problems and prevent them from occurring. Based on research into the insurance business, Crocker & Morgan (1998) suggest that a main role of contracts is to prevent the same mistake from happening again.

6.3.2 Purpose

Even though the definition of a contract, according to Major and Taylor (1996), states that a contract is made after an agreement is reached between parties, it was observed that both the OEMs sign contracts before the intention is reached in many instances. As a result, there are still fights over responsibility, costs, timings, quality, etc., after the contract signature. This demonstrates that the basic purpose of a contract, i.e., to reach an agreement acceptable for the contractual partners, is not fulfilled. If such basic premises are not met, trust and partnership will fail to emerge.

If the elements contended in the contract are not agreed upon, the contract will not be well defined, and the validation of the specifications may be difficult as the "what" to be validated will not be clear. The very purpose of contracts is to set the scene so that no conflicts will occur or so that the partners know how to deal with conflict (Major & Taylor, 1996).

The present study complements this conclusion by emphasising that everything cannot be made clear from the first instant, and hence validation of the agreements on a regular and ongoing basis may become an additional purpose of the contract. Neither the OEM nor the supplier should expect and specify the impossible. The purpose of a contract could be to oblige a clear discussion of what is expected and what is not, what is acceptable and what is not, and what is possible to anticipate and what is not. This is applicable not only to what the suppliers promise the OEM or to the demands of the OEM, but also to the generators of the specification that need to better know the capabilities of different suppliers.

To aid in this process, successive agreements have to be reached in order to validate common understanding of all sorts of compromises that the final product - the car or the aircraft - is subject to. The attitude to reach agreements and to assume changing situations (which could be chaotic at times) could be seen as a validation criteria for entry because, without the right attitude, the suppliers cannot be expected to deliver as promised.

6.3.3 Responsibility

Responsibility might not simply mean stating a list of tasks for the supplier to do. It also means ensuring that the demands are met and validated in a timely fashion. There is a need for the responsibility to be clearly visible and appropriately linked to the job at hand. I will illustrate the above statements better with an example.

A supplier was hired for design only and the contract ended when the supplier submitted the drawings. However, it was very difficult to judge the effectiveness of the drawings at an early stage in the development. Another supplier (who only manufactures and does not have any input in the design) manufactured the parts according to the drawings given by the design supplier and faults were noticed, as defective parts were being produced. But by the time the defects were noticed, the drawing supplier was already off the contract. Hence the OEM had to assume the changes in the design alone. The manufacturing supplier was of little help due to its lack of experience in solving design-related problems. This meant wasted resources and duplication of work.

The example shows that the quality of the specifications was affected by a misjudgement of the responsibility level of the supplier. Had the supplier been given both development manufacturability responsibility, then the supplier alone would have been responsible for solving all the design-related problems that became visible in manufacturing.

A very important part of the contract is to validate that the OEM gets what it asks for. The supplier responsibility, the OEM responsibility, and the joint responsibility may be made clear from the beginning and mentioned in the contracts. This is to avoid over- or under-management of suppliers. In the example above, the design supplier could have been contracted at least until the design had been validated in ramp-up production. The case of air bags to be fitted on to the dashboards further illustrates this point. In case of failure of the air bag under use, will the responsibility lie with the OEM, the dashboard supplier or the air bag supplier, both the suppliers, or all the three partners? For example, if the OEM clearly indicates that the dashboard supplier is solely responsible for air bag integration, then the sphere of responsibility for all the three players would be clearly visible.

The possibility of making responsibilities clear from the beginning would form the validation criteria for entry, as it would improve visibility should problems arise. It would lead to faster problem solving time. It might not only mean that the OEM alone articulates what the suppliers' responsibilities are, but the suppliers do the same based on their capabilities and capacities. The suppliers need to become more proactive and ask relevant questions to the OEM in order to take their part of the responsibility for integrated development. This could avoid missing areas when the OEM alone dictates what the supplier is responsible for. Understanding responsibilities would allow the supplier to understand the importance of quality, and continuous education and training in order to satisfy the demands of the OEM. Increasing levels of quality, continuous education and training would thus form validation criteria for remaining in the business.

6.3.4 Performance criteria

The contracts [A,B,C,D] judge suppliers on the dimensions of service, price and quality. The essential role of the contracts was to express these parameters in quantitative terms that, ideally, should be agreed to by both parties. However, all of the following selection factors, identified from the literature as essential for good relationship and product performance, were not considered:

- the suppliers capability in general to contribute to the OEMs product development process,
- technological and innovation capabilities,
- the *potential* for price reduction,
- suppliers' financial stability,
- environmental standards,
- supplier industrial relations,
- strategic, tactical, operational and interpersonal integration.

This indicates that the auto OEM has a narrow vision of performance criteria in its contracts focused on price, quality and service. The concentration of price as a selection criterion is in complete opposition to the argument that price should be the consequence and not the initiator of the discussion (Frey et al, 1993; Lamming, 1993).

Contract E in the aircraft OEM takes an additional factor into account, namely delivery performance. They have, in fact, hired a company to monitor the delivery so that they get the information as soon as the goods have left the suppliers. This means that instead of having many people monitoring the delivery, both at the aircraft OEM and at the suppliers, there is only one monitoring unit.

The performance criteria of the suppliers will impact on the quality of the specifications. For example, if suppliers are selected with no connection to the specification at hand, then there is little hope that the specifications will turn out as planned. Relating to the supplier typologies proposed by Kamath & Liker (1994), open specifications cannot be given to contractual suppliers for example. Also, giving detailed specifications to a partner supplier would be considered an act of over over-management. Although there will be generic parameters that are applicable to all these suppliers, there will also be some specific parameters in the contracts that depend on the specific capacities and capabilities of individual suppliers.

There is no doubt that a reasonable initial cost level at the suppliers forms an important criterion during the first discussions between the OEM and the suppliers. However, the attitude to price reductions is very important as the business dealings commence. Unless the supplier is financially stable, he will not be able to invest in productivity improvements and thus not be able to reduce the prices for the OEMs without reducing profit margins. The question of cost reductions, as well as parameters such as continuous improvement and innovation capabilities, are very much related to the culture, mission and strategy of a supplier. The opportunities for developing integrated buyer-supplier visions, and a fit of the mission, strategy and culture between and within the buyer and the suppliers can be seen as validation criteria for entry as they form the foundation on which business can be conducted.

Concern for sensitive issues like emissions and recycling matters must also be reflected in the initial discussions between OEMs and suppliers. This is to ensure that the suppliers can deliver within the constraints faced by the OEMs. Concern for environmental issues can be seen as an important criterion for entry as it determines the constituents of the product and the processes that the suppliers use. Questions on compatibility can be addressed at the beginning so as to reduce the problems that may occur during the development process.

Closer integration between the buyer and the suppliers at the strategic, operational, interpersonal and tactical level will lead to better understanding and improvement in the productivity during the development process. However, these cannot be achieved at the start of the relationship and hence it is necessary that they be achieved during the course of the relationship and can be seen as validation criteria for remaining in the business.

Another important performance criterion for suppliers was observed to be a fit between the suppliers existing portfolio of projects and the new projects accepted. Suppliers cannot be expected to have individual projects for every OEM without any synergies between them. It is essential to have synergies between the projects and this will be possible when the suppliers work with the same segments OEMs/demands. A clear explanation of the portfolio of projects by the suppliers to the OEM/s may be seen as a validation criterion for entry as it makes the assumptions clear from the beginning.

6.3.5 Legal issues

Although there are provisions for legal fines in the contracts, essentially for suppliers not delivering on time, they are not strictly enforced, as it is hard to determine where the fault lies. Also, the fact remains that if there is a high penalty, the supplier will be unwilling to sign any contract. On the other hand, there can be legal fines based on the specific demands placed on the supplier that are explicitly mentioned in the contracts. For example, if the supplier is asked to fulfil a certain durability demand and he does not do so, then he could be asked to reimburse the cost for that part. Let us assume that the cost for a product such as an equipment option sold to the OEM is $150 (the actual cost to the supplier is $100) and the OEM sells it to the importer at

$200. In case of rejection by the customer, the supplier has to pay the OEM $200 plus interest charges and not just $150. This is because the demand was to satisfy the durability requirements for the final customer and not for the importer or for the OEM. The example demonstrates that fines should be directly linked to the responsibility assigned to the suppliers.

I will take another example. The OEM had passed a component, which was 95% complete compared to the specifications, into customer cars. This was because the OEM judged that the 5% incomplete specifications concerned minor issues that would not be noticed by the customer. If the customer notices the defects, then the OEM will be blamed, as they passed the product and are responsible for the overall quality of the car. While the suppliers can be penalised for not satisfying specifications given to them or agreed upon with them and thus bear the warranty costs, the OEMs would be required to accept and reimburse losses in cases of incomplete specifications, wrong specifications, design miscalculations, interfacing problems between the components from different suppliers, etc., i.e., if the source of problems originated due to the OEM. This example shows that the problems were due to the poor usage of the contract as a mechanism for validating the requirements. If the contracts could make the responsibilities clear from the beginning such as that of the OEM and the suppliers, then the contract could function as a validating mechanism.

In a related example, Sorabjee (1997) comments that a steel supplier and steering gear supplier are jointly footing the bill for having supplied defective steering gears to a particular automotive OEM, thus paying for the recall exercise (where a number of cars were recalled) of the OEM. This confirms the fact that when the steel was accepted for use in the steering gears, the steering gear supplier accepted full responsibility for its quality. However, since the quality of the steel was bad, he footed the bill together with the steel supplier as it was the steel supplier's mistake to supply defects and the steering gear supplier's mistake to accept defects.

The ability to understand the legal demands and liabilities on a continuous basis would form a validation criterion for remaining in the business. This can also be seen as continuous environmental scan by the suppliers in order to aid the OEM and also to make the products with the right ingredients[103] so that the final customers will accept them.

6.3.6 Communication

Communication between the buyer and the supplier is all the more necessary given the fact that their work is interrelated. The outcome of the specifications depends on the in-depth discussions and joint problem solving carried out by both the buyer and the supplier. Contracts could also state when design reviews should take place and what information should be made accessible at such occasions. The contracts can assist communication by making sure that both the buyer and the supplier have compatible modes of communication and know-how, for example for EDI. The suppliers are increasingly under force to adopt Odette[104] as a means of communication. As most of the suppliers to the auto OEM supply to multiple customers, the investment in Odette would be considered to be specialised unless the suppliers use Odette in dealing with other customers as well. Common communication standards can be a vehicle for cross-organisational learning (Soderquist & Nellore, 2000). Either the auto OEM can encourage all other automotive companies around the world to adopt Odette or adopt itself to a common industry standard. If there are common standards, the suppliers do not have to invest in specialised transmission modes for each customer, and information will not be distorted in case cross-organisational learning is desired.

Contract E uses communication as both an entry criterion and a criterion to remain in the business. For example, if the OEM sends a message to the supplier, the supplier may have to respond immediately, and if possible with a decisive answer or at least with a message indicating when this answer will be ready. In the aircraft OEM, a small technical problem can cause the whole aircraft to shut down. Hence, the buyer and supplier are required to work very closely together at any moment to be able to solve the problems immediately they occur. Lacking a common information system there might lead to problems in understanding and working with the specification.

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[103] This means in order to meet the rules and regulation of the different countries.

[104] Odette is a communication system that identifies the protocols that have to be used between the buyer and the supplier. For example, the composition of a delivery schedule, invoices, etc.

Good communication means timely information about different parameters that require attention in specifications. In outsourced product development there are constant changes on the acceptable level of quality, cost, and service by the OEMs even after the contracts have been signed. While changes are a necessity, the amount of change is not mentioned in contracts. For example, it was not mentioned that there would be x loops of changes, or how many hours the changes would require. This meant that the OEM could easily be cheated into losing money. The contracts can state the number of hours, cost per hour and the maximum loops of changes. In the aircraft OEM, all changes are negotiated. Price increases are tolerated for materials and labour according to an escalation clause which works with a predetermined formula. In order to keep the competitiveness of the suppliers, the aircraft OEM reduces a small percentage of the escalation price. The aircraft OEM is prepared to pay any cost, as safety is of utmost consideration. Early decisions on changes allow that the specifications are satisfied within agreed costs. It also allows both the buyer and the supplier to understand all the possible changes so that there are no surprises when the specifications are to be validated.

The existence or strong potential for development of a common information system between the OEM and the supplier would form the validation criterion for entry. Without common information systems, there could be distortion of information, delays in reception, etc. The ability to estimate changes and avoid movements outside the set of solutions, costs and delivery conditions would allow the supplier to be validated for entry. Ability to work with a set of solutions is a critical success factor of Toyota according to Ward et al. (1995). The commitment to work within a set that includes cost, number of solutions and changes, extends the conclusions of Ward et al (1995). It is not only sets of solutions that are important, but also the ability to work within a set of changes and costs that are equally important. This appears to be an important validation criterion for remaining in the business as the existence of a continued profitable relationship depends on reducing costs and bringing to the market the best solution when required.

6.3.7 Payments

A lot has been written about the successful Japanese practices of early supplier involvement. However, the case companies rarely want to exchange information regarding their cost structure and production planning, something that might indicate a lack of trust in the suppliers (Helper, 1991). This leads to the conclusion that while the Japanese may be right in not relying on contracts but on long term partnerships based on trust, Western OEMs may be committing a big mistake if they think that this can be replicated overnight. The Japanese have taken years of working together with the suppliers to attain their current levels of partnership (Lecler, 1993). For example, other suppliers pitched in when Aisin, a Toyota supplier, caught fire and Toyota helped in reimbursing all the suppliers for their assistance (Nishiguchi et al, 1998).

Monetary resources are important for the continuation of businesses. The suppliers need information about payment schedules in order to plan their activities. They often think that if they deliver early, they might receive early payment. This was, however, very rarely the case. By clearly defining pay schedules in the contract, mistrust due to misunderstandings between the partners could be avoided. For example, in the aircraft OEM, the cost of each prototype is quite considerable. Hence the suppliers are told from the beginning that their products will be paid after delivery to the final customer. That is because the OEM also gets the payment after delivery. If long-term relationships are desired, then both the parties can share the risks.

In order to develop a healthy relationship, a number of activities can be undertaken at the start of the business and others could be undertaken as the business progresses. For example, the issue of payment can be made clear from the start so that activities can be planned accordingly and can be seen as a validation criterion for entry. Timely dispatch of information such as budget release dates, would help develop trust during the course of the business and hence can be seen as a validation criteria for remaining in the business. Validation criteria do not have to pertain to the suppliers alone. They could also pertain to the OEMs. Both parties can contribute their best in order to see that the final product is validated.

6.3.8 Specification – Contract link

Contracts should help in assuring that the necessary steps to achieve the specifications will be taken by the suppliers and the OEMs. The specifications are an essential base before the contracts are to be signed because without the specifications, it would be hard, even impossible, to understand the expectations in terms of cost, quality, lead-time, functional performance, and so on.

Specifications are subject to changes as the development projects proceed. However, the basic component or system concept needs to be explained to the supplier at design outset, and the contract process can be helpful in doing that. Changes mean risks to both the buyer and the supplier.[105] If the suppliers are to enter into long-term relationships and become an integral part of the development team, then the risks should be shared (Asmus et al, 1993). Contracts can confirm that suppliers estimate the number of change loops in the specifications, and quote a price accordingly. If there is a saving or increase in price, then it can be shared between the partners. However, with this technique the project estimates will go up initially.

The notion of autonomous or systematic technology[106] is important in the specification process. The current contracts in the auto and aircraft OEMs do not analyse this, however. If the supplier understands the technology that he is working with, then he will quote for jobs that can be carried out within his existing infrastructure of process technology and competence. This will lead to satisfaction within the supplier, as he does not carry out jobs that are beyond his capability.

The specifications normally outline several critical parameters such as materials, dimensions, product and process technology, testing procedures, and number of possible changes. Contracts could play an important role of checking that the suppliers understand these criteria. For example, a certain supplier knew that testing had to take place, but did not understand the importance of testing during the designated time period [which was winter]. The supplier carried out tests during the

[105] The risks could be that more money is spent than initially estimated, the concept turns out to be very different at the later stages in the development and hence has to be started all over again, the project is scrapped, etc.

[106] Autonomous technology does not require complementary investments in manufacturing or managerial processes, whereas systematic technology requires complementary investments.

autumn and was happy to be ahead of schedule. The result was that the components had to be re-tested in the right conditions, and this test revealed problems, leading to redesign and delay. Another example concerns the aircraft OEM, where only two prototypes can be built due to cost considerations. One prototype is used for destructive testing while the other is used for functional testing. The nature of the tests can be important and clarifying this to the suppliers as early as possible will allow the suppliers to build the prototypes with the right constituents[107] for the different tests.

Specification generation is interdependent between the buyer and supplier. There is a need for co-ordination and development of a common cognitive ground between the people involved (Karlson, 1994). This means that specifications cannot be simply handed down from the buyer to the supplier. Instead, a seminar could be utilised in order to discuss the issues in the specifications so that the concerned people can get together and discuss the alternatives and options. Contracts can state the conditions for these seminars and help in validating that both the buyer and the suppliers have understood the importance of having them. The seminars could be useful in articulating events that require the suppliers' physical presence (Karlsson et al, 1998).[108]

It was observed during the course of the interviews that benchmarking was an important requirement if the specifications were to take account of changing situations such as changes in the competitor offerings. Contracts can emphasis the importance of benchmarking both for the buyer and supplier. Furthermore, they could state how suppliers would deal with supply to several competing OEMs.

[107] Different prototype tests require a different level of ingredients or level of perfection. The early prototype tests do not require a high level of perfection as compared to the prototype tests conducted later in the process.

[108] When the suppliers quote for the contract, they often do not do any intellectual work, i.e., asking questions of why, what, etc., about the parameters in the specification. For example, when a supplier quoted for door trims, he did not realize the temperature implications. This was because of their desire to get the contract at any cost. When the car was tested in a Strategic Middle Eastern Country, where temperatures are extremely high, the door trims melted. This was because the supplier did not estimate the impact of temperature. The supplier had to change the door trims, which implied a price increase for the auto OEM. The suppliers can easily misunderstand and underestimate the critical nature of activities unless they questions the importance of each project with respect to the portfolio of projects that they are engaged in.

There are a number of messages from the above analysis. Getting feedback from each other (buyer – supplier) seems to be both a validation criterion for entry and a validation criterion for remaining in the business. If there is feedback from the early stages of the relationship, then development of trust can be facilitated. Understanding the tests, their nature, validity, and the right period to execute them appear to be important criteria for remaining in the business. If there is poor understanding of the product at hand, then there are bound to be problems. This understanding could be extended to suppliers' physical presence on project platforms. In certain cases, the physical presence of the suppliers is required and the suppliers may have to promote this understanding at the early stages of the relationship. Having a separate project team for each of the OEMs with synergy effects[109] between them can be seen as an important criterion for entry into the business. This is because the suppliers will be able to devote adequate attention to the needs of the individual OEMs, which may be different. Benchmarking throughout the development process, and providing evidence of it at the outset and throughout the duration of the project will be necessary. Finally, the use of seminars to reflect around the specifications will be seen as a validation criterion for remaining in the business. This is because the development staff will be more willing to accept the specification as a working document rather than a document that is to be written just for the sake of writing it (Smith et al, 1991).

6.4 The elements of a Contract to validate the specifications

The above section has analysed the different types of contracts. The analysis indicated that the different contract categories can be split into validation criteria for entry - to be used before the supplier starts the business - and validation criteria for remaining in the business - to be used after the supplier starts working with the OEM (Table 6-3). The understanding of the two different types of criteria and the classification of the different contract categories into these different criteria appear to be important in order to validate the specifications. The criteria developed in Table 6-3 are the outcome of the analysis, the observation of the different contracts, and the interviews.

[109] The project teams need to be dedicated to the individual OEMs but experiences, etc., can be shared.

ID	Parameter	Validation criteria for entry	Validation criteria for remaining in the business
1	Types	• Clear linkage between the contract and the types of suppliers	• Continuous input of clauses to prevent mistakes from reoccurring
2	Purpose	• Ability to reach agreements and feel comfortable with uncertain situations	
3	Responsibility	• Ability to make responsibilities clear from the beginning • Number of Value added questions asked • Demonstrating both internal and external commitment to the project/s	• Increasing levels of quality • Increasing education and training
4	Performance criteria	• Development of visions for suppliers • Understanding of the mission, culture and strategy [both OEM and the supplier] • Concern for environmental issues • Match between the project and the portfolio of projects	• Show strategic, tactical, interpersonal and operational integration as time passes
5	Legal Issues		• Ability to understand and estimate legal, liability issues, etc.
6	Communication	• Common information systems	• Ability to work within a set that encompasses solutions, cost and changes
7	Payments	• Clear proposal of when, how and the parameters on which the payment will be made	• Timely dispatch of information such as budget release dates
8	Specifications	• Getting feedback • Having separate project teams for the individual OEMs • Early benchmark report before the start of the project	• Getting regular feedback • Understanding the tests, nature of the tests, etc. • Use of seminars to discuss the specifications • Benchmarking throughout the project

Table 6-3, Validation criteria's for entry and for remaining in the business[110]

The two types of validation criteria must be separated, as suppliers can remain in the business and yet not deliver what they are asked for. The OEMs seemed to either ignore the difference between the validation criteria or did not pursue the two types of criteria in full vigour.

110 The two shaded boxes represent the fact that no explicit criteria could be developed for the stated parameters

The checklist proposed in Table 6-3 is a set of issues that can be included in the contract to assist validation thereby adding to the list of partnering activities, leading to satisfying results. These questions can either be asked to the supplier during auditing, or be articulated by the supplier on his own. For example, both the OEM and the supplier can check whether suppliers' visions are present. Understanding the tests would mean to decide who should do what in the tests. This means that each validation parameter is discussed between the parties in the broadest sense.

I will take an example to demonstrate this. The auto OEM engaged a telephone supplier to develop an integrated telephone for a new model. However the protocols in the telephone change once every six months and the OEM was not aware of this. Since the auto OEM project got delayed, the protocols changed and thus the OEM had to remove the option of installing the integrated telephone. Using the strategic validation contract could have helped avoid this. For example, getting feedback as a validation criteria for entry, at the start of the business, would have meant a clear articulation between the parties about the protocol life cycle and this could have helped the auto OEM to understand the relation between the change in the protocols and the length of delay of the models.

6.5 Conclusions

The examination of the contracts leads us to the conclusion that contracts can be used as a driver of the specifications[111] by considering a number of factors. The contracts can help OEMs as validating mechanisms in their dealings with the suppliers. Table 6-3 shows that the contracts can be split up into two criteria, namely the validation criteria for entry and the validation criteria for remaining in the business. Validation criteria for entry stipulates that the suppliers are capable of understanding the business, while the criteria for remaining in the business stipulate that the suppliers deliver according to what has been mutually agreed upon between the buyer and the supplier. The contract can also be a forum for raising questions, for example, when the supplier is asked the state of the art, it means a certain technology is demanded of

[111] The contract being projected in this thesis is a unified approach to dealing with the different internal demands such as from engineering, purchasing, manufacturing, commercial departments and thus, present a united front to the suppliers'. This means that the demands of all the various internal parties will be communicated together within the same contract to the suppliers.

him which is not in the market. If the supplier does not ask any questions, for example, about interfaces, then it is highly probable that the suppliers will not be able to identify common themes, dissimilarities, etc. The need to reach agreements on an ongoing basis was also found to be important when dealing with suppliers. Failure to do so was observed to lead to problems as a complex product like that of an aeroplane or an automobile built on compromises.

The next chapter is the concluding chapter where the contributions to current knowledge will be identified by comparing existing literature to the current findings.

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Introduction

This chapter is structured around the main research questions and answers each fully. It discusses the findings for each of the research questions and presents the final conclusions. The contributions of the present study to existing knowledge are discussed. It is not the aim of this thesis to present the reader with the thought that the conclusions reached here are the only possible ones, but rather to emphasise that these are possible ways of observing the role of specifications and contracts.

7.2 The Research Questions

The aim of the research questions was to explore, describe and generate recommendations in order to understand the roles of specifications and contracts in outsourced product development in the automotive industry. Let me recall the main research questions from Chapter 1 as follows:

- ***What is the role of specifications in integrated development between the OEM and the suppliers?***
- ***What is the role of written contracts in assisting the validation of specifications in the development process?***

Detailed research questions, have been answered in the analysis chapters (Chapters five and six) and hence I will answer the main research questions in this chapter. The answers to the detailed research questions will help to answer the main research questions laid out at the beginning of this research. The detailed research questions pointed out that specifications can have multiple roles such as communication roles, outsourcing decision roles, etc., and these will be discussed in the next section.

7.3 Role of specifications

The findings from the first research question on specifications will be related to the existing studies and in the process synthesised so that contributions to existing knowledge can be arrived at. It was observed that there are several roles of specifications and they are discussed as follows:

7.3.1 Role of specifications in guiding outsourcing decisions

The outsourcing decision is complex. There are a number of authors who state the importance of different elements that need to be considered in the outsourcing decision. An inexhaustive list would include Quinn & Himer (1994), Fine & Whitney (1996), Clark (1989), Blonder & Pritzel (1992), Lamming (1993), Venkatesan (1992), etc. It has been argued earlier in Chapter 2 that the outsourcing decision cannot be based on one element alone. For example, the supplier should not be encouraged based on the fact that he has a low cost base, but rather there are a number of elements that need to be considered such as the attitude, the technology, etc. Some of the authors like Quinn & Hilmer (1994) have grouped parameters and thus made it possible to make the outsourcing decisions on a number of parameters, instead of individual parameters.

Specifications were identified to be on a continuum from purely narrative to purely quantitative. There were several elements like styling, which could be described only in narrative terms, while simple components could be described in purely quantitative terms. Some elements like the chassis were described by a mixture of both qualitative and quantitative terms. The complexity and subjectivity in judgement were found to decrease when the specifications move from being purely narrative to quantitative, while the resources required and the level of detail was found to decrease when specifications move from being quantitative to narrative. The difficulty in the ability to simulate increased when moving from quantitative to narrative on the continuum. The degree of outsourcing would depend on the OEMs decision on the type of specification. The more narrative a specification, the harder it would become to articulate it to the supplier and thus the specifications would be kept in-house. This is also observed in Toyota[112] where the styling[113] of the car is kept in house. The more "purely" quantitative a specification, the easier it is to hand it over to the suppliers for development and manufacture. Products that lie in between the narrative and quantitative dimension can be given to external suppliers for manufacture, but would need a range of partnership relations to assist in the making of the product. This complements the work done in decision making for outsourcing.

As outsourcing decisions include a complex web of factors, it would be interesting to compare the role of specifications in outsourcing decisions with respect to the model proposed by Quinn & Hilmer (1994) and the model proposed by Venkatesan (1992). The reason for doing so is that they have developed explicit parameters that can be used to make outsourcing decisions. Quinn & Hilmer (1994) propose that the goods to be outsourced would depend on the potential for competitive advantage and the degree of strategic vulnerability. Quinn & Hilmer (1994) consider two dimensions, but the degree of strategic vulnerability can be complemented by an additional dimension, i.e., the specifications. In other words, the more narrative the specification, the harder it is to specify requirements to the suppliers and the OEM may become highly vulnerable if it did so. Hence, narratively specified products would be made in-house, while purely quantitative specifications would be outsourced in the adversarial manner and finally, specifications in between the quantitative and narrative continuum would be outsourced[114] but cushioned by a range of relationships like close partnerships, joint development, etc. Quinn & Hilmer's (1994) model is a narrow perspective and is not broad based, but then again a model cannot contain all the perspectives and is constrained. Also Quinn & Hilmer's (1994) model is at a strategic level and is hard to be applied to the working level of the developers. The complementing of Quinn & Hilmer's (1994) model by the specification perspective can help to apply it to the working level, for example, at the level of the design

[112] Observed during my visit to Toyota (March, 1998) and benchmarked during detailed interviews conducted with General Motors Executives also during March, 1998.

[113] Despite the fact that Toyota engages in insourcing styling it does not mean that other automotive companies like Nissan, Honda and Volvo do the same. The reason to outsource/insource a narrative specification like styling would very much depend upon the strategies of the firm in question.

[114] It appears from the case studies that items that are narrative in nature would be kept in house. This is because they are hard to describe internally within a firm and trying to describe it to an external supplier would be even more difficult. Having said that, I still observe many companies to be outsourcing narrative specifications. This has been further researched in a published paper in Omega, which is attached in the appendix.

engineers. The current research also helps to complement Venkatesan's (1992) model on what to outsource. While Venkatesan (1992) comments that strategic items should be made in-house and develops a list of parameters that are characteristic of strategic items, the current research identifies that the character of the specification could be an important distinguishing characteristic of strategic items. In other words, those specifications that are hard to simulate or are normative would be classified as strategic and kept in-house.

It may be appropriate to link the above discussions to the suggestions of Clark (1989). If items lie on the critical path, then concurrent engineering may be used to reduce development lead-time. In concurrent engineering, it may be beneficial to have the suppliers develop the parts if they have the technology, have the capacity, can reduce costs, etc. Specifications that are on the critical path and are objective or quantitative may be best suited to be outsourced. This is because the specifications do not need further discussions, thus saving time and money, which is important in the critical path. Specifications that are purely narrative would require extensive discussions between the designers and personnel involved, as they are extremely subjective. It may not save the OEM any time or money to outsource these, as the subjectivity involved may actually prolong decisions thereby increasing the converging and diverging phases of the specification.

Specifications that are a mixture of quantitative and subjective criteria may or may not lie on the critical path. If the specifications lie on the critical path and save the OEM resources, then they can be outsourced. Outsourcing on the critical path is a risky process and hence, there is a need to reduce the risk by making decisions which are based on a number of decision parameters. However, whether the outsourcing saves resources would be a hard estimate. The evaluation cannot be made on objective criteria alone and needs to have an estimate of the long-term impact, for example, the suppliers attitude, etc. It appears to be hard to agree with Clark (1989) that only critical items should be outsourced. Firstly, in product development it is hard to estimate the critical path because the development people find it hard to see it as a process (Adler et al., 1996). Thus it will be hard to find out the critical path and the exact items to be outsourced. Specifications, on the other hand, allow the developers to find out the critical and non-critical items as discussed above.

Secondly, there could be items that the OEM may want to outsource whether or not they lie on the critical path. Specifications help to reduce the confusion by linking the actual nature of the parts to be outsourced/insourced to the actual decision of outsourcing or insourcing, depending on the OEM's strategy.

It would be useful to observe whether there are any disadvantages of looking at the role of specifications in outsourcing decisions. Literature has shown that many engineers are averse to writing specifications. People just want to have a document called the specification and use it to prove their innocence in case things go wrong. If that is the situation, then it may be difficult to visualise people using specifications as an aid in their decisions about outsourcing. This means that a change in mentality is required. Top managers think that specifications are the business of engineers and they do not have to be involved.

When starting this research, the author also felt that specifications were the domain of engineers. But using specifications for decisions on outsourcing means that every function in an organisation can use them. The use of specifications in outsourcing decisions would mean that OEMs have to think through what they want from the suppliers, which kind of suppliers they want and the exact division of labour between the buyer and the supplier. This could assure a better understanding of what to outsource. The company in this research does not use specifications in their decisions on outsourcing matters. This is because of the fact that they are afraid of specifying what they do not know.[115] Also, if the role of specifications has to be accepted in an organisation, greater emphasis must be laid on developing specifications and specifying both matters that are easy and hard to describe. For example, if the Vice President of a firm decides that the materials cost will decrease by x percent, then one can turn to the specifications for help. Perhaps specifications could be given to the suppliers or specifications could be pulled in-house to aid the process of material cost reduction.

[115] For example, when engineers are asked to develop a reverse warning system, they may be afraid of laying out the exact specifications as they do not know the location of the system, the possible usefulness of the system at an early stage, etc.

Even engineers, after sales staff, the indirect material purchasers, etc., will be able to easily decide on what to outsource and not to outsource. The author sees the future role of specifications in outsourcing to be very promising. There has been a lot of talk about outsourcing, but this concept links the actual work of the people to the decision on outsourcing. If a specification already exists, then it could be tailored in the direction of outsourcing or in-house development/production. However, a major problem exists with this thinking as engineers and others in the firm who are concerned with job losses as a result of outsourcing may create the specifications so that they are normative, all the time. This, coupled with the current mentality in the industry that the OEMs job is not details but the overall vehicle, could lead to problems. This means that the top management in engineering, purchasing, etc., may not check the specifications very carefully and thus many items that could have been outsourced will now be made in house.

Specifications are visionary at the start of development and become more precise as time progresses. This poses a challenge, as people will be forced to think about specifications sufficiently early. In other words, specifications will have to be worked upon early enough as in the case where the engineers champion that the specifications are visionary all the time, then all the specifications will have to remain in-house. If specifications are to be outsourced, then there has to be more thought given to their shape early on in the process. Overall, this role of specification in outsourcing decisions will require a complete change in mentality, the way suppliers are treated, etc. The above discussion illuminates the role of specifications in outsourcing decisions and thus answers the research question on the role/s that they can play.

- ***Contribution to knowledge:*** *Specifications can be used in decision making when making the vital decision of whether or not to outsource. By taking specifications into consideration along with a number of parameters (already proposed by current research) and linking them to the actual work of the development staff, the make or buy decision can be improved. In particular, specifications can be used to complement Quinn & Hilmer's (1994) model and Venkatesan's (1992) model of strategic outsourcing decisions. The findings also link the specification to the critical path analysis as developed by Clark (1989). The findings project* *specifications as an easier way to make decisions about outsourcing than finding out the critical path (Clark, 1989) since it is hard to estimate (Adler et al., 1996).*

7.3.2 Role of specifications as a means of communication during the development process

Current research regarding specifications is very internally focused. Communication is discussed within an organisation and not between organisations, which is pertinent when discussing outsourced product development. Almost all the authors, like Clark & Fujimoto (1991), Karlson (1994), Smith & Rhodes (1992), Roozenburg & Dorst (1991), neglect the suppliers. Both the scientific and practitioner views of product development (Karlson, 1994) lack explanations of communication patterns when suppliers are involved. The contribution of this research in general is to extend the research done in communication within an organisation to between organisations that are important in outsourced product development. The specifications are shown as the means of communication, which are visionary at first and then grow in content towards the later stages of development.

Current research on the flow of information in product development is internally focused and does not talk about relationships between firms, even though authors like Karlson (1994) and Söderquist (1997) comment that development work is interdependent between the different functions that are involved (which could include suppliers as well). This may appear to be inconsistent as in the case where there is outsourcing of components/systems there is more parallel development with overlapping product development stages. One would expect to see more discussion about the flow of information between partners like the OEM and the suppliers. Even in the practitioner view of product development, since there is a need for alternating between the whole product and the individual parts that constitute the part, involving suppliers means that there must be more emphasis on the flow of information between the buyer and the supplier. This is because the supplier may be making the parts (halves) while the whole product (together with critical parts, systems, etc.) is made by the OEM. This demonstrates that there is a need to observe and capture the process of collaboration (such as flow of information, exchange of personnel, etc.) between the buyer and supplier.

Specifications certainly help to understand the flow of information, as they are an arena for collaboration. It could be assumed that many authors did not see the importance of discussing the specifications between the buyer and the supplier. This is because the specifications were very internally oriented within the OEM and the fact that the industry was passing through a very difficult transition phase, i.e., from being a vertical integrator to allowing suppliers to develop complex systems, which were previously done internally.

The specifications were generally developed by the OEM in some form or other and then worked on by the supplier. The fact that specifications formed an arena where the OEM and the supplier could get together, discuss, collate and then record the information were grossly ignored.

The specifications allow information from the different departments to be available to all concerned in the development process at any point in time. Specifications allow developers to capture the past, current and future models and thus allow for discussion around the same. Specifications need to be written and to be used as a working document in order to reap the benefits that they can offer. This means a change in the mentality of the developers who are used to carrying all the information within themselves. They must allow the suppliers access to this information and allow the information to be shaped by them as well. Specifications change from being visionary to being more specific as development progresses. This certainly calls for more exchange of information and discussions during the visionary stages so that details can be sorted out at an early stage itself. This will allow for greater parallelism between the buyer and the supplier and also allow iteration of information. Also, the specifications allow for the different actors to work together and realise the product, which is a result of the interdependence between their individual tasks.

Smith & Rhodes (1992) express the view that specifications are visionary at first and then as time passes, with the addition of more information, the specification becomes both bulky and specific. This can be seen as the traditional or scientific view as everything is taken to be orderly and rational. Kaulio (1996), on the other hand, sees the process of specifying as a converging/diverging process where information reaches a bulky stage after the diverging process and then, as the information converges through analysis and synthesis, the bulkiness of the specification reduces. This can be seen as the practitioner view as there is iteration between the whole product and the parts that constitute the whole product. This is similar to the two ways (scientific and practitioner views) of looking into the product development process as proposed by Karlson (1994).

The specifications must involve all the different departments. This means that information must be shared not least because the different tasks in product development are interdependent. This sharing of information may prove to be difficult for many reasons, such as the organisation structure, the threat of job losses, the fear of making mistakes, etc. Overcoming the initial problems and using the specification as an arena for co-operation would allow the different actors to come together and discuss. The specifications are an arena to make mistakes and learn from them. Only the final document called the specification must be perfect as far as possible. This certainly allows for a way to distribute information across all functions, as suggested by Nonaka (1991). However, the fact that the specification is a forum for discussion on concepts must be made clear.

In particular, the specification perspective complements Clark & Fujimoto's (1991) model of the product development process by also emphasising external communications. Clark & Fujimoto's (1991) model is very internal in outlook, focusing on marketing, manufacturing, etc., and does not take into account the external factors like suppliers, and other internal factors like after sales, etc. In outsourced product development, it is important that the development process accounts for the external factors as well. In the present research, the product development process is seen as a process where specifications are created over time and include both external and internal factors. Specifications are created continuously[116] and are generated through an interactive process.

The information asset framework observes specifications to be generated only during the product planning stage (Clark & Fujimoto, 1991). The present research expands their specification idea from one stage only to cover the entire four stages[117] of the

[116] Please refer to Chapter 5 for a detailed overview of the specification model.
[117] Clark & Fujimoto indicate 4 stages (concept generation, product planning, product engineering and process engineering) in the development process.

development process, thus depicting specifications as a way of communicating and ultimately managing the development process. The present research observes the product development stages as a process where a series of specifications satisfy the requirements of producing the product and thus describe how to communicate during the four stages of the development process. The specification perspective magnifies the dialogue that takes place between the internal and external developers throughout the process. Hence the different types of specifications (content, level of detail, etc.) can be seen as additions to the four stages of Clark & Fujimoto (1991). However, the bottom line is that both Clark & Fujimoto's (1991) model and the process suggested by this research help us to achieve the product and are complementary ways of conceptualising the product development process. Finally, describing the product development process by way of specifications provides an accessible means of communication amongst those involved in the development process.

The flow of information between the OEM and the supplier is not well documented. Many of the models of specifications, like those developed by Smith & Rhodes (1992), Roozenburg & Dorst (1991), are internally oriented within a firm. The specification perspective complements the specification models of Smith & Rhodes (1992) and Roozenburg & Dorst (1991) that are internally focused and concerned with the communication patterns within a firm. The specification perspective extends their work to developing a specification model that encompasses both the buyer and the supplier and thus the communication patterns between them.

- ***Contribution to Knowledge:*** *Specifications can be seen as facilitators of dialogue in the development process. Specifications consider both the actors, namely the buyer and the supplier in the communication patterns. They complement Clark & Fujimoto's (1991) model by including external parties like suppliers and also propose a pattern for the flow of information between the actors involved in the development process. Current research also projects specifications as an arena to bring together actors of different professional affiliations, facilitate the communication between them and thus help to increase the integration of the tasks/s. This complements the work done by Karlson (1994) and Söderquist (1997) who only indicate the importance of the different actors working together. Current research also indicates that the specifications can be studied with respect* *to two different schools of thought, namely the scientific and the practitioner viewpoints. The current research complements the work done by Nonaka (1991) by indicating a channel for distribution of information not only within a firm, but also between firms like the buyer and the supplier. It also extends the models of specification proposed by Smith & Rhodes (1992) and Roozenburg & Dorst (1991) to include suppliers and thus propose communication patterns from within a firm to between firms.*

7.3.3 Role of Specifications for deciding the time of involvement of suppliers

Research has indicated that there could be different kinds of suppliers. If there are different kinds of suppliers, then they may require different types of information and at varying time periods in the development process. Specifications could consider the different modes of communication, i.e., certain suppliers need certain modes of communication. The serial mode of communication was found to be suitable while dealing with contractual suppliers, the early involvement mode for mature suppliers, the integrated problem solving mode for partner suppliers and lastly, the early start in the dark mode for the suppliers transiting from being child to mature suppliers. This was observed to be a useful way of deciding when to involve the suppliers in the specifications. However, this would require a clear supplier classification on the part of the OEM. If suppliers were to be wrongly classified then there could be problems, for example, a child supplier being involved in early discussions with the OEM. This would mean a waste (time, energy, etc.) on the part of the OEM and the supplier, as the supplier understands only detailed drawings, whereas the OEM wants a discussion partner. This mismatch in expectations could lead to problems.

This indicates that the Wheelwright & Clark (1993) models on communication can be complemented. Wheelwright & Clark (1993) only comment on the different modes of communication but do not take into account the fact that there could be different types of suppliers.[118] It is important for firms to identify the different types of suppliers and then use the relevant communication modes. If there is a mismatch between the supplier (for example a child supplier) and the mode of communication (for example, early involvement), then there could be problems, as the child supplier will not be able to contribute to the learning process that the OEM desires.

Separating the suppliers into different categories and then determining appropriate modes of communication has its advantages and disadvantages. The advantage lies in the fact that the suppliers will get information as and when required according to their capabilities and capacities. This will also help prevent misplacing the supplier into the wrong category, thus saving both the supplier and the OEM time and money. The disadvantages could lie in the fact that the suppliers may be continuously growing out of one category. Thus there is a need to continuously monitor the growth of the suppliers and consequently OEM's may have to engage full-time staff to follow it up. Also, many suppliers may lie in between two categories. Hence, companies may have to create more categories according to the situation and develop the appropriate communication modes. Not many companies currently engage in separating suppliers[119] and then developing appropriate communication modes. This could certainly be seen as an important element that would separate well performing

[118] Lamming (1993) discusses two ways in which the supplier can present himself to the assembler, namely as a leader or as a follower. Within these two modes there are two possible strategies that can be adopted, namely the key player or the loyal collaborator. As a key player the supplier establishes a technological lead, be a first tier supplier – direct or indirect, have a global presence, have a policy of acquiring technologies, etc. As a loyal collaborator, the supplier is not an equal contributor to the OEM but an unequal responsive partner. The supplier has a presence in non-automotive markets and has a competence in specific component technologies. As a leader, the supplier leads the OEM in several operational aspects like quality, etc. As a follower, the supplier may choose to limit his automotive investments. In the above context the message of Lamming (1993) is that there are different types of suppliers who may require different modes of communication. But this is at a higher level or a strategic level and is hard to be applicable to the working level. Lamming (1993) does not discuss all the possible types of specifications or all the communication modes. For example, the central communication message of Lamming (1993) is that the key player will need early joint discussions while the loyal collaborator supplier may need late communication. However, there is no clear match between the types of suppliers and the different possible communication modes.

[119] "The author has worked as an operational responsible with General Motors Corporation, Scania and Saab Automobiles. The author has also consulted with many different manufacturing firms like Saab Aerospace, Rolls Royce, Nissan Motor Manufacturing amongst others and not found the concept of supplier categories in place. The author has also identified that companies such as BMW have adopted the concept of supplier categories.

companies from the poor performers. The task of joining the communication modes to the categories of suppliers seems appropriate as not all suppliers are equal and each category has a separate set of needs[120]. Also communication modes alone do not suffice. Even if the communication mode is appropriate, the form of communication needs to be tailored to the capacities and capabilities of the suppliers. For example, the child suppliers may be using a communication mode such as serial interaction but would require a form such as a drawing for the serial mode of communication. On the other hand, partner suppliers may require a functional specification and not drawings and prefer the integrated problem-solving mode of communication. The form of communication essentially points out the creativity in communication, which according to Alexander (1985), is important in good communications.

The creation of categories for the different suppliers would mean that both the OEM and the supplier would know what to expect from each other. This would lead to fewer tensions between the buyer and the suppliers. Reduction of tensions can lead to better relations and development of trust between the buyer and the suppliers. Trust would lead to more openness and less restrictiveness, which corroborate the findings of Schein (1985).

If the communication patterns are clear, then there could be a positive impact in the dealings between the OEM and the suppliers. I will demonstrate this with an example where the communication patterns affect the supplier structure. Clear communication patterns could allow the formation of close relations with the suppliers who deal with multiple functions (mega systems[121] suppliers), followed by system suppliers (who deal with a single function) and then all the component suppliers. There could also be a special kind of suppliers called the expert suppliers who specialise in a particular technology like Brake Systems, etc. This is shown in Figure 7-1.

[120] This thesis makes an assumption that no supplier will lie at the margins of the above-identified categories. This is because even if a supplier lies at the margin of a certain category he still belongs to the category unless otherwise mutually determined between the OEM and the supplier or by the OEM. If the fact that suppliers lying at the margins need to be taken into account, then the complexity for supplier category management becomes complicated for the OEM's.

[121] This paper is forthcoming: R. Nellore, (2000), Purchasing Today

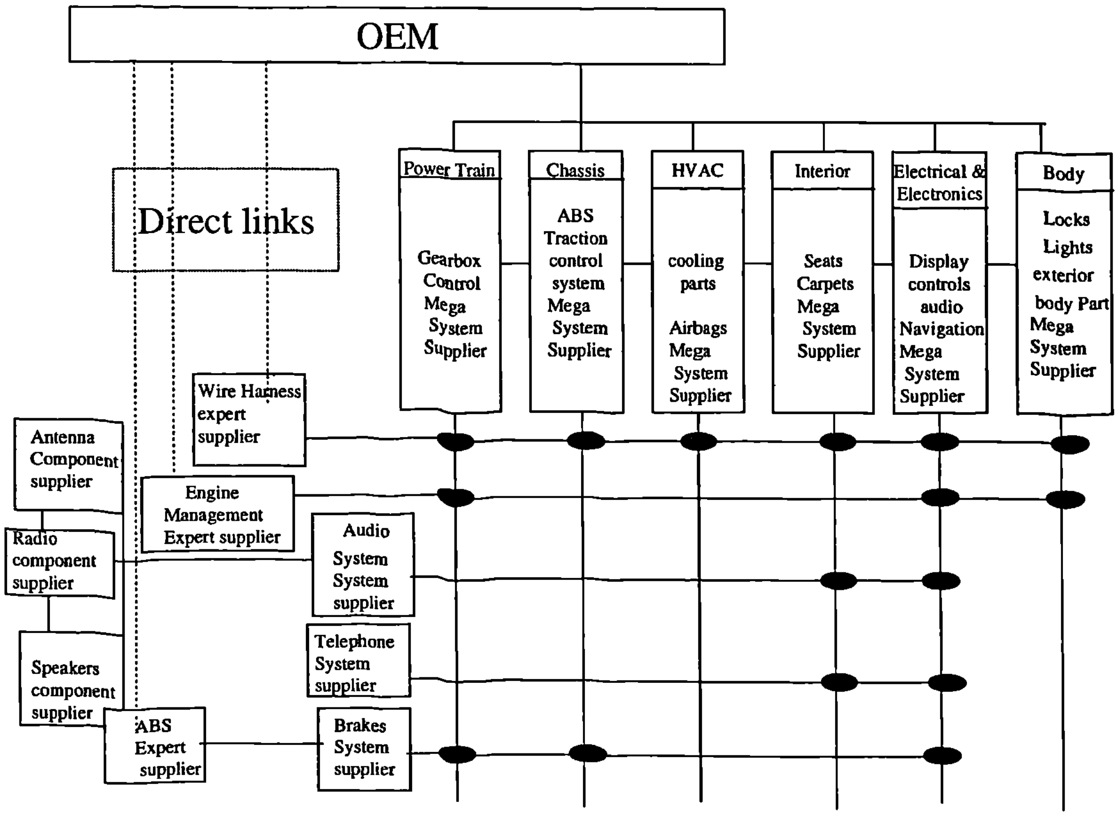

Figure 7-1, The mega-system approach (Source: author)

Figure 7-1 is an understanding of the way the identified suppliers can be employed. The OEM firm deals with the mega-systems suppliers who are responsible for the integration of more than one function in the below mentioned areas such as power train, chassis, etc. There is joint responsibility and if one supplier fails, then the whole system will collapse. The expert suppliers in this example are the wire harness supplier, the ABS supplier and the engine management supplier. The OEM has direct links with these suppliers in order to develop their competencies and to keep in touch with the technologies that the product will be utilising. The system supplier in this case is the telephone supplier and the audio system supplier as they satisfy a function. The audio function system supplier deals with the radio supplier, antenna supplier and the speaker supplier. This function is satisfied by interfacing with the mega-systems suppliers of electrical and electronics, and the interior supplier.

So invariably the system moves from a push (where the OEM created all the specifications and gave them to the suppliers) to a pull system where the suppliers generate the specifications as and when required. This model will actually mean a reduction in the number of suppliers and the clear visibility means easier control.

There is shared risk-taking which means that if one supplier messes up the whole car is messed up. Depending upon the option of product development responsibility, the OEM may actually have direct links, for example, with suppliers other than the systems supplier like the wire harnesses supplier.

- ***Contribution to knowledge:*** *All suppliers are not equal and hence need to be involved at various stages in the development process. Involvement in various stages also has implications for the types of information and the mode of communication to the supplier/s. Present research complements existing research of Wheelwright & Clark (1993) by linking their categories of communication modes to the different types of suppliers as proposed by Kamath & Liker (1994). This also extends Lamming's (1993) concept of supplier – communication mode link from a higher level to a workable level. Present research also indicates the form of communication for the identified categories of suppliers thereby complementing the work of Alexander (1985), i.e., suggesting that the form of communication is a creative communication skill. Current research also contributes to the fact that the clearer the communication patterns, the more positive the impact on the development of a supplier structure.*

7.3.4 Role of Specifications in differentiating Suppliers

Suppliers have been observed to be of different types, thus requiring different communication modes from the above section. Specifications were observed to be one mode of separating or categorising suppliers based on the workload that they can handle. This corroborates the findings of Kamath & Liker (1994). This could be seen as an approach whereby suppliers are classified according to their capabilities and capacities. The capability of the suppliers was found to affect the way they interpreted and dealt with the specifications. Existing theory like that of Kamath & Liker (1994) points out that there are different types of suppliers like partners, mature, child and contractual suppliers. However, it was not pointed out that there could be a network of suppliers such as a mature supplier dealing with a number of child suppliers which has been dealt with by Lamming (1993). In effect, the specifications would need to be written with consideration for the capabilities of all the suppliers involved in the network. If the specifications are written without any consideration for the capability levels of the suppliers, then there could be problems, as many suppliers may not understand the demands on the industry, for example, the finishing requirements in the premium segment of the automotive industry. Child suppliers and the like can belong to different industries and thus not understand the way the automotive industry operates. This means that the future prospects of specifications being able to differentiate suppliers would depend on the ability of specification writers to integrate and specify with the consideration of the frame of reference of suppliers belonging to other industries. This is a complicated task and can be eased by considering the exact number of suppliers, their interconnections and then splitting the task of writing the specification according to the capabilities and capacities of the suppliers.

The connection between the type of specification and categories of suppliers is analogous to the connection between the mode of communication and the categories of suppliers. The advantage of the connection between the type of specification and category of supplier is that the suppliers are given work that they are best at doing. They will not be placed in the wrong category and given work that is beyond their capacities and capabilities. Without the appropriate capabilities and capacities, the suppliers will not be able to work with the specification. Since specifications haven't been given enough attention in research or in practise (such as making the specification a corporate issue), not many companies have been able to benefit from the connection between the categories of suppliers and the type of specifications.

Even if the suppliers are in four distinct categories, as indicated by Kamath & Liker (1994), there is no guarantee that they will do as they are told or as mutually decided. All too often, suppliers promise a lot and do much less than what is promised. This could be due to two main reasons, namely the segment that the suppliers cater to and their interest in the project and their knowledge base. Same segment suppliers[122] are better able to understand the demands placed on the OEMs than other segment suppliers. If the suppliers knowledge is poor, then they may make promises based on misunderstandings. Hence the categories of suppliers must be complemented by the knowledge – importance link (Figure 7-2) as follows.

[122] Same segment suppliers are those that supply to the OEMs that are in a common segment like Audi, Volvo, Saab are in the luxury segment.

The categories of suppliers will help better understand the suppliers needs and then deal with them accordingly. For example, the categories of suppliers can be treated according to the importance of the project to them in terms of turnover, innovation, etc., on one hand, to the amount of knowledge that they posses on the other hand. This is summarised in the Figure 7-2 below. If the knowledge and the importance of the project to the supplier are high, then there can be an atmosphere of trust and regular checks made at major gates in the specification. On the other hand, if the knowledge is low and the importance is high, then detailed specifications could be provided to the suppliers. If the knowledge and the importance of the project to the supplier are low, then the supplier may be allowed to deal only with contractual products. Lastly, if the knowledge is high and the importance is low, there may be excessive control with major checks at a number of minor gates; in other words, policeman techniques may be used. Putting suppliers into different categories allows OEMs to deal with suppliers in a manner that befits them. In other words, the different categories of suppliers can be now matched to the importance- knowledge framework and then the appropriate mode of dealing with them can be selected.

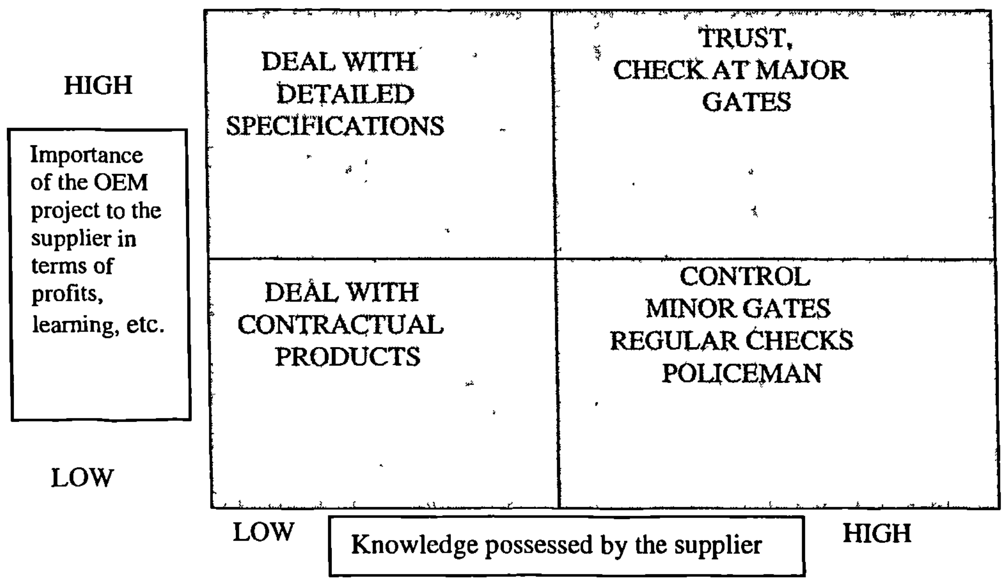

Figure 7-2, The supplier knowledge importance link[123] (source: author)

[123] The different actions that are recommended may be taken by the OEM against the suppliers.

Contribution to Knowledge: *Specifications were observed to be one way of separating suppliers. The content of specifications was observed to have a direct link to the capabilities and capacities of the supplier. The present research observes that suppliers are of varying capabilities and capacities (corroborates the findings of Cusumano & Takeishi, 1991-who also categorise suppliers, Kamath & Liker, 1994) and are tied together in a network, which corroborates Lamming's (1993) findings. If the specifications do not consider the network and the capacities and capabilities of the suppliers, then there could be problems, as the suppliers further away*[124] *from the OEM may not understand its requirements. The present research contributes to existing research, like that of Kamath & Liker (1994), by extending their concept of the different types of suppliers to the fact that the specifications would be required to consider the capacities and capabilities of all the suppliers involved in the network. Current research also indicates that matching different categories of suppliers to the importance – knowledge link would lead to better management of supplier relations. Engaging suppliers that deliver to the same segment OEMs could also facilitate the management of specifications.*

7.3.5 Role of Specifications as embedding competitive advantage

Specifications were identified to have both static and dynamic parts[125]. This was seen as an extension of the approach of not only collecting information (Smith & Rhodes, 1992; Söderquist, 1997) about specification parameters, but also classifying them as static and dynamic. If the time period for parts to change from static to dynamic or vice versa could be estimated, then there could be a competitive

[124] Could be 2nd tier, 3rd tier suppliers, etc.

[125] The term dynamic refers to new technology and static could refer to current or carry over technology in making parts, i.e., components, systems, etc. A radio could have both static and dynamic parts. For example, dynamic and static parts can be classified both between projects and within projects. The dynamic parts between cars could be instrument panels, radio-which will be integrated with the navigation system, climate control-which will use the same display as the radio and the navigation system, etc. The examples of static parts would be the steering wheel, chassis, etc. Within the development of a product there could be both static and dynamic parts. For example, during the making of a radio the static parts are the physical dimensions and the location of the knobs, but the functionality of the radio is dynamic (the functionality of the radio had changed completely from the initial specification to the prototype stage). Initially the seek button in the radio was to have a functionality, so that a soft push would put it to automatic seek while a hard push would put it to manual seek. However, at the prototype stage the functionality was such that a soft push would put it to manual and a hard push would put the seek to automatic. The realisation of the type of technology would help to understand when to work on the specification and to delay it and when to freeze the specifications at an early stage.

advantage. For example, the wire harnesses are currently static in the car, but if optic fiber technology is developed and used, they could become dynamic. This means that the level of innovation in the product would be just right and the developers will be able to focus their energies in the dynamic areas. This also indicates that the final product does not need to be built from scratch all the time and can use carryovers. This has implications for the time to market, as customers can wait only for a certain period for a new product.[126] If the product is not available when the market expects it, then there could be problems. This can be overcome by working on the static parts as early as possible. Only certain areas, as dictated by either the customer or by the technology, need change. In other words, the product will not have to be built from scratch all the time if the right amount of static and dynamic areas are identified from the start of the project, i.e., the right level of innovativeness must be present. If products are presented to the customers who do not expect them or can't afford them, then there is a high chance of failure. One can look at the Concorde aircraft to understand the problems of presenting technology, which the customer does not expect and/or cannot afford. If parts are outsourced, then this information could be communicated to the supplier through the specifications, which also reduces the time to completion.

Contrary to Smith & Reinartsen (1991), who emphasise that there are a certain number[127] of different elements in the specification, it has been observed that the number of elements are not the only important issues, as the extent of static and dynamic parts within the specification are also important and value adding. Perhaps the previous studies were interested in all the different types of information that could be written in a specification, as opposed to the value of all the elements in the specification. This could also be traced back to the fact that the automotive industry, where most of the previous research lies, has been very internally oriented and the specifications were thus generated to suit the internal employees. There was little consideration for the external parties like suppliers who were basically making parts to detailed specifications. The transition from the phase where suppliers did not contribute to the knowledge of the OEM to the phase where the suppliers were

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[126] In the recent strike at General Motors (1998), many customers who were waiting for the new models switched to offerings from competitors such as Ford, Chrysler, etc.
[127] There were 32 elements that were identified.

responsible for entire systems, was a painful process. The OEMs used the same type of specifications and thus the suppliers were subject to undue interference by the OEMs. During the first phase of the transition, the most important thing was to convey as much information to the suppliers as possible. The second phase, which is currently being written about in this research, is about the need to differentiate between the suppliers and to give them specifications and communicate with them according to their capabilities and capacities.

It is hard to estimate the change over from static to dynamic and vice versa. Engineers engrossed in current technologies may be reluctant in accepting ideas about new technologies and thus ignore the change over from static to dynamic and vice versa. It could also be attributed to the "not invented here" syndrome. Many developers may be reluctant to predict the change over for fear of castigation if they are wrong. Many top managers may be cut off from reality and fail to understand the importance of changing technology. This indicates that if specifications are to perform the role of providing advantage, then there has to be a radical change in how people think and work. This may also mean that newer ways of working may have to be developed. The notion of dividing parts into static and dynamic will allow the lead-time for the development to be reduced. This is because the number of options that will be investigated will lie in the dynamic areas. This could be useful especially when many researchers like Fujimoto & Thomke (1998), Clark & Fujimoto (1991) are stressing the importance of lead-time reduction in development.

The identification of static and dynamic technology can help in moving the OEM towards being both competent and conscious of the situation; in other words, being competent and being aware of why one is competent. The worst case scenario can be when one is both unconscious and also incompetent. Here the products may turn out to be bad and yet one may not know why the products turn out that way. In order to improve the situation, one possible scenario would be to improve the consciousness and then improve the competence. This means that once the understanding is improved of why things go bad, action will be taken so that they are not repeated. This will then be followed by an increase in the competence. The identification of static and dynamic technology falls in the path of improving awareness and thus being conscious, as it allows people to be aware of the technology that they are dealing with.

Therein lies the larger issue of dealing with increases in competence that should go hand in hand with the awareness part.

- ***Contribution to Knowledge:*** *The number of elements that are communicated in a specification to the supplier is not in itself, sufficient. The present research indicates that the division of all the elements into static and dynamic parts will help the developers to reinforce their energies in the dynamic parts. The present study contributes to the model of Smith & Rhodes (1992) by extending the number of elements that they propose to the need to classify these elements as static and dynamic, namely that proposed by Hollins & Pugh (1990). This was observed to be the case as the automobile is a compromise between time, money, level of innovativeness, learning, etc., and thus might not have to be started from scratch each time a new one is built. The concept of dividing into static and dynamic parts allows a reduction in the diverging phases (as proposed by Kaulio, 1996), as the number of ideas to be generated will lie in the dynamic parts. This extends Kaulio's (1996) concept of the converging and diverging phases. This research also extends the lead-time reduction concept of Clark & Fujimoto (1991), Fujimoto & Thomke (1998) by providing an additional sphere where lead-time could be reduced. Current research also describes the role of identifying the static and dynamic technology as an important first step in creating awareness within the organisation that should then be followed by an increase in the competence within an organisation.*

7.3.6 Strengthening Specifications through visions for suppliers

Specifications allow companies to distinguish between suppliers so that visions can be developed for the different categories. In other words, specifications help to categorise suppliers who would then need visions so that there are no false expectations between the buyer and the suppliers'. Visions affect the core capabilities in the buyer – supplier relationship. Four layers of visions were developed for the different types of suppliers. In relation to theory, it is observed that the Bowen et al (1994) model deals with internal visions and visions for external parties like suppliers are not considered at all. The development of visions[128] for suppliers, though relevant, seems to have been less researched. Lamming (1994) also observes the growing trend towards the partnership models where suppliers are treated as equals and yet does not talk about visions for suppliers[129]. Without the visions, how would the staff in the OEM know how to deal with the suppliers? Visions were observed to be the sum of the mission, culture and strategy of the company, thus corroborating the findings of Lipton (1996). Hence, it becomes all the more important for the OEMs to articulate whether its employees would allow the close relationships with the suppliers, whether there is a clearly defined aim of where and how the suppliers are expected to contribute, the strategies for involving the supplier, etc. This was observed as a result of the analysis. The specifications allow the suppliers to be categorised[130] so that visions can be developed for the different categories. It allows the developers to know in which direction they are moving or should be moving as far as the suppliers are concerned. The importance is further corroborated by the observation that the visions could affect the type of knowledge sought from the supplier and also the attitude towards the supplier. The concept of visions was observed to be important not only inside organisations but also for organisations dealing with external partners. The more developed and articulated the visions are for the suppliers, the better are the chances that the suppliers can be involved in the development process and will be allowed to work subject to their capabilities and capacities without undue interference from the OEM.

There could be disadvantages with visions as well. For example, many different types of visions have been proposed, such as visions for suppliers, product concept, etc. These can cause confusion, as people may not be aware of which vision to remember. However if the visions are decomposed and broken down into the different types (i.e. all the visions are related to each other) then these problems can be minimised. Looking into the past would make it apparent that very few companies

[128] The concept of Visions for Suppliers was presented at the 5th International EUROMA conference (Dublin, 1998) where the plenary session Chairman Prof. Roger Schroder commented that the concept was very innovative

[129] Not all suppliers can be treated as equals as they must be treated in accordance with their capabilities and capacities. A vision explains this to the organisation and also lays guidelines as to how the different types of suppliers need to be treated. A vision for a partner supplier talks about equality whereas the visions for Mature, Child and Contractual suppliers do not talk about equality.

[130] Kamath & Liker (1994) develop four categories of suppliers who are distinguished from one another by the type of specifications that they require. The visions can be developed for the identified categories of suppliers.

ever thought about development and deployment of visions. Today, many companies are trying to develop and deploy visions as part of the list of critical success factors that a company needs to possess. The benefits of a well-developed vision can only be reaped when companies do not use it as a piece of paper that can be filed but instead use it as a working document. The creation of specifications could reflect the visions of the company for the employees, the product, the business, and the suppliers.

The visions can affect the skills that an OEM may want to posses. For example, the OEM may allow the supplier to develop skills in certain components/systems that it may not consider being important. However, the OEM may pull these competencies in-house if it feels that the technology driving the system/competency may become critical to its survival. The vision for suppliers will also affect the style of the OEM staff. It will allow the OEM staff to display appropriate behaviour to the supplier that befits their capabilities and capacities. This also means that they will not mismanage their supplier. Visions could also affect the staffing level. If suppliers could do most of the work, then staff levels can be reduced in the OEMs. The structure could also be affected by visions. The visions through their influence on strategy, skills, staff etc. will allow the formation of newer forms of governance that will essentially affect the structure of the organisation. Finally, visions could affect the systems that are used in the interchange with the suppliers. For example the use of CAx (computer-aided design and computer aided manufacturing) may become mandatory for all suppliers that are expected to contribute to the knowledge of the OEM. The above discussion indicates that visions for suppliers affect McKinsey's 7s[131] framework.

- ***Contribution to Knowledge:*** *Clear identification of suppliers and development of visions for dealing with all the identified categories of suppliers was observed to be important in working with suppliers. This contributes to existing research (Bowen et al, 1994) by extending the concept of visions from within a firm to between firms, like the OEM and the supplier. The concept of visions corroborates Lipton's (1996) findings that visions are the sum of the mission, strategy and culture of the company. Current research also complements the systemic model (McKinsey's 7s model), by extending it from analysing the*

[131] McKinsey's 7s was not discussed in the literature review. This is because the conclusions indicate the extension of the 7s model. The 7s represents the strategy, structure, shared values, systems, skills, staff and style.

strategy of a strategic business unit to analysing the relationship between the strategic unit and its suppliers.

7.4 Role of contracts

I will firstly recapitulate the research question on contracts and attempt to relate the observed conclusions with the existing studies and in the process synthesise so that contributions to existing knowledge can be arrived at. The research question is **"What is the role of written contracts in assisting the validation of specifications in the development process?"** It was observed that there are several roles of contracts and they are discussed as follows:

7.4.1 Role of Written contracts in reaching agreements

Contracts have not been seen as instruments that could assist the specifications by existing research. Comparing the current findings with Major & Taylor (1996), it becomes clear that they only discussed the different types of contracts but failed to explore their relevance to the specifications. While they discuss several types of contracts, the current study points out that the written contract is most helpful in assisting specifications, as validation elements are explicit and are thus hard to be misinterpreted or forgotten. The use of written contracts is seen as one of helping to achieve the relationship contracting situation (Hakansson, 1982). Major & Taylor (1996) also point out that the contract is signed after an agreement is reached. The current study points out that it is very hard to identify or agree to all the parameters right at the start of a project like that of an automobile. The automobile is a trade-off and thus the agreement would have to be made on an ongoing basis. Hence, the contract has to be seen as a vehicle that allows the parties to cross check and verify that a vast number of elements are carried out. Thus, the contract is not a static piece but rather a dynamic piece that drives the specification – both the process and the document. There could be possible disadvantages of looking upon contracts as drivers of the specifications. If agreements have to be reached on an ongoing basis then it could imply uncertainty. Uncertainty requires that people (buyer and supplier) feel at home with ambiguous situations. According to Ward et al. (1995), many of the suppliers to Toyota could not handle uncertain situations. This would certainly require a lot of groundwork in the sense of selecting people, working with ambiguous targets, etc. A written contract could mean that every thing is documented and bureaucratic. It could allow the main essence of innovativeness to be cushioned by rules and regulations. Perhaps even decisions that need to be made on the spot will take days. In other words, if contracts are to be used as documents driving the specifications, then there must be an attempt to preserve the spontaneity within the contractual process. Reaching agreements on an ongoing basis implies the basic assumption that all attempts will be made to improve the suppliers and work with them, whereas having flexibility in the contracts (Harris et al., 1989) implies that the suppliers will be dispensed with if they do not perform. Therefore, in trying to use contracts as a validating mechanism, care must be taken to observe that the attitude within the OEM is one where supplier development will be encouraged.

- ***Contribution to knowledge:*** *The written contracts can be used to reach agreements on an ongoing basis in the specifications. Since the automobile is a compromise, agreements will have to be reached on an ongoing basis and hence the contract can be seen as a vehicle that helps to attain these agreements. This contributes to existing knowledge (Major & Taylor, 1996) by observing that the contracts are not just signed after an agreement, but instead strive to attain and fulfil agreements on an ongoing basis. The use of contracts as a vehicle to reach agreements requires a different approach to suppliers than that proposed by Harris et al. (1998), i.e., suppliers must be seen in the long term and all attempts must be made to help the suppliers.*

7.4.2 Role of written contracts in validation

The examination of the contracts leads to the conclusion that they can be used both as commercial documents and as drivers of specifications by considering a host of factors like culture, compatibility, etc. (Beecham (1996), Goffin et al. (1996), etc.) Since the contract projected as a result of this study uses the elements identified above in its content apart from others, it would be appropriate to comment that the findings of the above authors are corroborated. When the present study is compared to existing studies like Asmus & Griffin (1993), it becomes clear that existing studies have not taken into consideration the contents of a contract in order to validate the specification. Cooper (1975) & Beecham (1996) have indicated that contracts can be used as validation mechanisms and since this thesis is able to demonstrate this, the work of Cooper (1975) and Beecham (1996) is corroborated. Asmus & Griffin (1993) talk about best practice contracts, but do not explain what their content is. The current study splits the contracts into two parts, namely the validation criteria for entry and the validation criteria for remaining in the business. Validation criteria for entry helps the OEM to judge whether the suppliers are capable of understanding the business, while the criteria for remaining in the business helps the OEM to judge whether the suppliers can deliver according to what has been mutually agreed between the buyer and the supplier. Both the validation criteria for entry and for remaining in the business form the contractual structure, which can help to achieve integrated development between the buyer and the supplier. This means that both the OEM and the supplier will be able to validate whether they can achieve the specifications. If the characteristics of the suppliers are not checked, then it could be problematic, as the OEM will be unsure that the supplier will be able to deliver. The criteria for entering into a business are different from the criteria that are necessary to remain in the business. In other words, once the supplier enters into the business he needs to be validated on totally different criteria as opposed to those that were used to allow him entry into the business. The clear audit at the start of the relationship can help avoid misunderstandings. The contracts can help OEMs, as validating mechanisms in their dealings with the suppliers, by checking that critical activities are fulfilled as and when required. The lack of existing research makes it difficult to pinpoint the exact contribution to current knowledge.

The concept of validation criteria for getting the business and remaining in the business can have limitations and advantages. The advantages are that the more thorough the content of the contracts, the more likely the success of the validation. There could be limitations, for example, on how to deal with a supplier who has done business with the OEM and then remained dormant for a period of time. Would this supplier have to be validated for getting into the business or for remaining in the business? Since the supplier has a gap in business dealings, he may need to be validated all over again (validation criteria for entry) so that the supplier is made aware of all the emergent issues. It could also be seen as a period of reorientation. If all the criteria can be part of a computerised information system, then the evaluation can be done in a manner that provides justice to all concerned. The collection of criteria poses another problem. Would all the criteria be measured objectively (quantitative) or subjectively (qualitative)? The more subjective the evaluation, the higher the chances that the validating officials may make mistakes. The more objective the criteria, the more likely the chances that the softer issues like attitude will not be taken into consideration. Hence, worthy suppliers may not be given a chance. One way of avoiding discrepancies in supplier evaluation would be to have a mixture of both qualitative and quantitative criteria for supplier evaluation. The advantage of the validation criteria allows the author to project it as the future evaluation scheme for suppliers in many organisations. Of course, the limitations will have to be overcome before the contract can perform its role.

- ***Contribution to Knowledge:*** *Existing research has pointed out best practise contracts but have not stated what should be contained in the contracts. Thus, this study extends the best practice propositions of Asmus & Griffin (1993) to actually developing the contents of a contract. The content of a contract to aid in validation appears to be more important than the distinction between the contracts used by a best practice company as opposed to that used by an ordinary company. The current research points out that written contracts can be used to drive the specifications and thus assist in their validation. This corroborates the findings of Cooper (1975), Beecham (1996), etc. The contract can be split up into validation criteria for entry into the business and additional validation criteria for remaining in the business. These elements will assist in the validation of the specification. If there is a gap in the supplier's dealings with the OEM, then the OEM may have to validate the supplier all over from the beginning, i.e., use the validation criteria for entry. This extends the limitations in the propositions of Cooper (1975), i.e., by developing the clear validation criteria for specifications and also arguing for the suppliers who have a gap in their business dealings with an OEM. This also confirms the fact that contracts are not a static document but are indeed dynamic.*

The entire discussion on the contributions to knowledge can be summarised in the Table 7-1 below. It represents a model of learning describing the differences between the current state of knowledge and the knowledge added by this research.

Role	Current State of Knowledge	Contribution to Knowledge
Role of Specifications in guiding outsourcing decisions	The existing models of outsourcing such as that of Quinn & Hilmer (1994), Venkatesan (1992), etc., do not take the nature of specifications into account.	The nature of specifications such as quantitative, qualitative or mixture of qualitative and quantitative affect the resource balance within a company and need to be taken into account in any model of outsourcing. Quinn & Hilmers (1994) and Venkatesan's models are complemented with the specification dimension in order to reduce the risk in the make/buy decision.
Role of Specifications in guiding outsourcing decisions	Clark (1989) elucidates that components/systems on the critical path should be outsourced though, Adler et al (1996) states that the critical path is hard to estimate.	The nature of specifications dictates whether they lie on the critical path or not. The nature of specifications can thus, be used to observe whether an item lies on the critical path thereby, functioning as a tool in estimating the critical path.
Role of Specifications as a means of communication during the development process	The information model by Clark & Fujimoto (1991) does not include external partners like suppliers'.	The description of a specification flow model incorporates both the internal and external parties thereby, facilitating communication between them.
Role of specifications in deciding the time of involvement of the suppliers	Communication Modes (Wheelwright & Clark, 1993) have no links to suppliers	All communication modes have been linked to the supplier categories as proposed by Kamath & Liker (1994).
Role of specifications in differentiating suppliers	Suppliers are of different types (Kamath & Liker, 1994)	Supplier types could be distinguished on the basis of specifications. These supplier types exist in a network and therefore, the capabilities and capacities of the network as a whole must be considered.
Role of specifications in embedding competitive advantage	Smith & Rhodes (1992) classify specifications as consisting of 32 elements.	The number of specification elements are not important rather, their classification into static and dynamic parts are more vital.
Strengthening specifications through visions for suppliers	Bowen et al (1994) elucidates that visions are internal within a firm.	Visions can and should be developed for suppliers' as they affect the core capabilities in the relationship with the suppliers'. Current research also complements the systemic model (McKinsey's 7s model), by extending it from analysing the strategy of a strategic business unit to analysing the relationship between the strategic business unit and its suppliers.
Role of written contracts in reaching agreements	Major & Taylor (1996) elucidate that contracts are signed after an agreement	Contracts can be used to reach agreements on an ongoing basis and not simply signed after arriving at an agreement.
Role of written contracts in validations	Beecham (1996) elucidates that contracts can be used for validation	An explicit list of elements that can be used to validate suppliers' both for entry into the business and for remaining in the business has been developed.

Table 7-1, A Summary of important learning

8. CONCLUDING DISCUSSION, MANAGERIAL IMPLICATIONS, LIMITS AND AREAS FOR FUTURE RESEARCH

The present study has explored the role of specifications and contracts in integrated product development between the case study OEM and its suppliers. Comparison interviews concerning the role of contracts were conducted in an aircraft OEM. The exploratory nature of the study, due to the very weak body of literature on specifications and contracts (the latter in the specific area of the research – outsourced product development between OEMs and suppliers), has provided a rich set of essentially qualitative data. The objective was to explore and describe the role of specifications and contracts in dept, not to conduct a comparative survey over different industries. Hence, I do not stress any generalisability of the findings beyond the theoretical generalisability outlined in chapter seven.

This chapter summarises the conclusions and presents the main managerial implications from the research. Limits and areas for future research are also discussed. For the reasons discussed above it is left to the reader to determine the applicability of these results to his or her own situation. Table 8-1 summarises the conclusions elaborated in chapter seven.

Role of Specifications	Role of Contracts
To help guide in outsourcing decisions	To help attain agreements on an ongoing basis both during entry and during the course of the business.
To help function as a means of communication	To help assist in the validation of specifications
To help decide the moment of involvement of the suppliers	
To help differentiate suppliers and thus understand the network of suppliers and tailor the specifications to suit the suppliers capabilities and capacities	
To create visions for suppliers and thus, clarify the expectations from the suppliers'.	
To help embed competitive advantage	

Table 8-1, The Integrated Conclusions

The priorities of these roles could change over time and also could depend on the various strategies for and/or phases of supplier relationship restructuring that OEMs are engaged in. For an OEM that has just started outsourcing, the role of specifications in outsourcing decisions may be more important than the other roles. For example, the research findings indicate that the nature of specifications, on a continuum from essentially narrative to essentially quantitative, is a complementary indicator (besides, for example, degree of competitive advantage, and degree of strategic vulnerability) of whether a development activity could be successfully outsourced or not. The more narrative the specification, the more difficult it would be to outsource as it would demand total mutual understanding of the problem at hand between the OEM and the supplier(s) in questions.

For an OEM already engaged in a portfolio of supplier relationships, and heavily emphasising outsourcing, the role of specifications as a means of communication, of optimising the moment of involvement of suppliers, of supplier differentiation, and of creating supplier visions could be leveraged.

For example, the role of specifications for outsourcing decisions can help speed up the development time. This will require the decision about the specifications to be made early enough in the development process. The role of specifications in communicating visions will allow the OEM to get the necessary information from the suppliers without placing the suppliers into the wrong categories. The role of specifications in communications is valid throughout the development process and also within the supplier network. The role of specifications in deciding the static and dynamic parts will also help to speed up the development process, as all the parts will not be required to be started from scratch. Certainly, the role of specifications has changed from being more operational to being a combination of both operational and strategic. This also means that specifications encompass all the levels within an organisation and not only the operational level.

The role of specifications as a knowledge gatherer (the distinction between static and dynamic parts), market investigator (allowing for communication between the different departments involved in the development process), analytic tool (communication between the different departments in order to analyse and synthesise information), and contractual tool (giving the specifications to the suppliers based on their capabilities and capacities) are corroborated. The role of specifications as a vehicle in the gate-keeping, idea generating, coaching, championing and project leading roles can be explained as follows. The use of specifications in outsourcing decisions can be seen as supporting the role of the champion. In other words, the champion can, with the help of the specification as an aid in outsourcing decisions, sell his idea within the organisation in favour of outsourcing or insourcing. The coach could educate the staff by explaining the role of specifications in outsourcing decisions. The role of specifications in separating the static and dynamic parts could be seen as supporting the gate-keeping role. In other words, the specifications keep track of all the new developments that could affect the transformation of the static parts in dynamic parts and vice versa. The clear selection of the supplier categories, the establishment of modes of communication, etc., allows for these roles to be performed. Contracts allow for both flexibility and a planned product by validating and reaching agreements on an ongoing basis. The role of contracts is strategic and important in obtaining the planned product. These roles appear to be the bane of the current practices in the industry, namely lean production. The roles of both specifications and contracts can be essentially seen as important success factors for sustaining and improving lean practices.

These roles point out directions if the OEMs are to make full use of their suppliers. It is not the intention of the thesis to present these roles as best practices, but rather see them as guidelines for development. The automobile is a complex product. As the complexity increases, the need for integration is all the more important. It also means that OEMs cannot concentrate on everything and have to concentrate at what they are best at, namely the overall vehicle architecture and leave the rest to the experts, i.e., the suppliers. The suppliers will be able to make the trade-offs in a well thought out manner if they are given total system responsibility, for example, to reduce weight, etc. The more the dependency on the suppliers for knowledge, the lesser the possibilities of making tight specifications and giving them to the suppliers.

8.1 Supplier Involvement and dependency on suppliers

Dependency on the suppliers can also be seen in the light of the involvement of the suppliers (Figure 8-1). Low dependency and low involvement were characteristics of the adversarial way of working. The "dream" of many OEMs is to have low dependency on the supplier and yet, have total involvement of the supplier. Such thinking can be utilised in strategic areas of the OEM where the supplier is given critical specifications. The supplier does the entire development and is motivated, while the OEM has the knowledge and thus control over the total specification. The OEM can work towards increasing the involvement of the suppliers through different means and, at the same time, not depend too much on the supplier for knowledge. A high dependency and high involvement would be characterised by partnerships and a well-developed relationship where specifications are jointly developed. Finally, a high dependency on the supplier who has a low level of involvement would lead to problematic situations which is clear in the case of technological bottlenecks, for example, the supplier may not provide the OEM with the latest technologies, not convey opportunities on technological breakthroughs, etc. The OEMs would have to either reduce the dependency or increase the involvement of the supplier in the specifications.

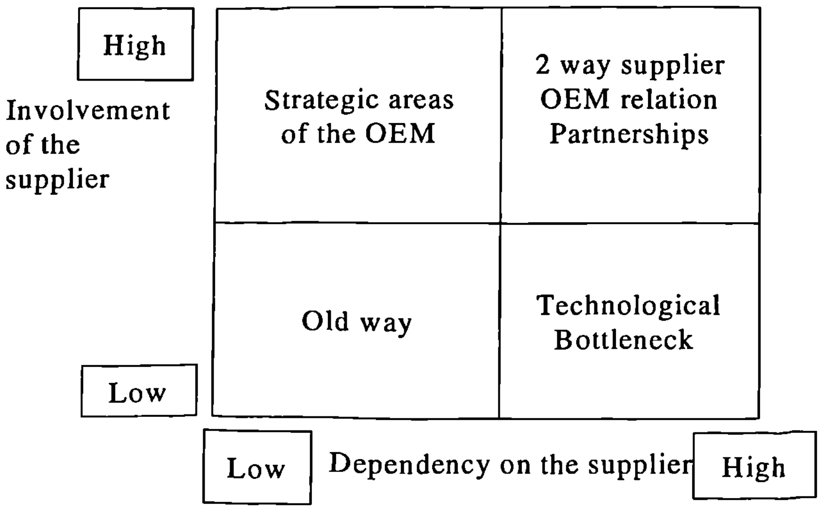

Figure 8-1, Involvement - dependency relation (source: author)

In the case of integration of complex subsystems there is a strict need for precision or else the systems will not fit together or the whole product, when assembled, will not function. As the demands on the first tier[132] suppliers are increased, they will also place higher demands on their own suppliers (2^{nd} tier). In many instances, these 2^{nd} tier suppliers may come from other industries and not understand the demands of the auto industry. The specifications may thus have to consider the needs of the network of suppliers and not just the immediate suppliers to the OEM. The trend in the auto industry is to use more of network of suppliers for R&D, as opposed to building huge R&D centres. This further illustrates the importance of understanding the needs and the roles of the actors in the network.

Treating all the suppliers as partners will not help the OEM, as they would be wasting time, for example, when asking for "knowledge" from a child supplier. The importance of innovation is ever growing. To be able to innovate and estimate the changes in technology is extremely important on the part of suppliers. Hence, it is necessary that the suppliers are classified and appropriate communication modes utilised in order to maintain the efficiency of the development process. Given the huge failure rate in innovative ideas, there may be a need for more experimenting and prototyping. The suppliers have to show failures and not only successes. Failures lead to better products and this very concept could be articulated between and within the OEM and supplier firms. A written contract could help in assisting this articulation. It is quite evident that the written contract is utilised because there is no trust. In countries like the United States, contracts exist for almost every transaction or occurrence, while in Asian countries like India, contracts are made reflective of the changing situation. This shows that written contracts are important as the West is far away from the trust-based relationship that the Japanese have. Finally, the use of 450 questionnaires allowed us to see patterns that could be reflective of the industry.

[132] These suppliers are involved in direct dealings with the OEMs

8.2 Supplier Involvement at different levels[133]

In the extensive review of literature, it was observed that there was a lot of commentary about the need for early involvement of the suppliers, and the benefits of early involvement. However, very little was said on the how to actually involve the suppliers. This has been observed by the author in the industry[134] where practitioners are disgruntled by the fact that they have very few tools to work with. This thesis is a step forward in paving the way for organising tools in order to facilitate early involvement (the "how" of involvement and not the "why" of involvement). Companies develop strategies at three different levels: the corporate level, the business unit level and the operational level (Johnson & Scholes, 1993). In the same way, if suppliers are to be involved, strategies for their involvement can be developed at these levels, as integration at the operational level (with the suppliers) does not mean integration at the other levels. Certain decisions or interactions with the suppliers will be at the business unit level or the corporate level. For example, while "visions" are more or less the domain of the corporate or the business unit level, the role of specifications for competitive advantage as "static and dynamic parts" is the domain of the engineering level. Many roles such as communication are transversal and affect one or more levels, etc. Finally, a complex product, such as an automobile, needs thousands of parts to work in unison. If the suppliers are to take on the daunting task of being responsible for complex systems, then failure on the part of one supplier could lead to shut downs lasting for days.[135] The need for co-ordination mechanisms, like that of specifications and written contracts, thus becomes all the more important in order to facilitate the harmonious working between the buyer and supplier and also between the suppliers themselves. Considering the example of Chrysler[136] can further ratify the importance of a well-planned supplier involvement strategy. The company has perhaps the highest rate of supplier involvement in the industry and also the highest warranty costs in the industry indicating that Chrysler may have to revisit their supplier involvement strategies.

[133] The final conclusions on contracts are built on the joint study between the auto and the aircraft OEM.
[134] The author currently used to develop procurement strategies for a heavy vehicle manufacturing firm.
[135] One can turn to the story of Ford being held as a hostage by a locks supplier during 1998, Source: Automotive News Europe
[136]The term Chrysler refers to the company before the mega merger of Diamler Benz and Chrysler.

8.3 Managerial Implications

The following recommendations for managers have been derived from the case studies. The validity of the recommendations has been tested with managers in the case study OEM (project managers, chief engineers, and Vice Presidents of all departments). However, the generalisability has not been tested, hence, each recommendation ends in a hypothesis that would need further research to be explored in more depth. Elements (1-3) relate to specifications while elements (4-6) relate to contracts.

1. Good specifications cannot be created with a high turnover of staff, as the organisation will have people with little or no experience of a complete project. Product development work contains both tacit and explicit knowledge. The writing of specifications requires both these types of knowledge. If people leave the organisation, then tacit knowledge is lost. This can be detrimental to the quality of the specifications. Organisations do not only have a formal reporting structure but also an informal structure. It has been observed that it is crucial to know the informal structure if one has to find answers or have decisions taken at least informally thus allowing the development to continue without breaks. Staff turnover can result in problems, as the new staff have to first learn the informal structure, which could then cause delays in the development. This has also been articulated by Bates & Slack (1998), who suggest that the success of the Japanese companies is based on their philosophy of life time employment that allows them to get the best out of their employees. Since the automobile builds on previous experience, the longitivity of tenure would be directly proportional to the quality of the automobile. It could be reasonable to conclude that the longer the tenure, the better the quality of the specification.
2. When writing specifications it may be necessary to consider the fact that the second tier suppliers (indirect product suppliers to the OEM) may belong to another industry and know nothing about the automotive industry and hence about the demands that the automotive industry is subjected to. Specifications may have to become tighter as they pass through the tiers to the bottom tier, thereby encompassing all the demands that could help the second and third tier suppliers to supply a component that fits with the demands of the industry. The deeper a supplier network is penetrated the greater the requirements on the completeness of

information. The further the distance of the suppliers from the OEM in terms of knowledge sharing, the higher the responsibility of the OEM or its immediate suppliers to provide complete knowledge in the form of drawings or simulated specifications to the suppliers.

3. The specifications could indicate whether the supplier is being hired for black box engineering, development work, grey box engineering, etc. This is necessary in order to avoid the confusion and duplication of work, by both the buyer and the supplier. If the type of supplier is mentioned, then it could be easy to decide the communication modes and ultimately, the extent of the suppliers contribution to the specifications. An ideal situation would be where an engineer would be able to state that he needed a black box (or any other kind) supplier and would hence utilise an early (or any other kind of mode) mode of communication. On the other hand, simply stating the work that the supplier will be engaged for is not enough. This is because it is not enough only to create the categories of suppliers, but it is also necessary to create categories of products. Then the categories of suppliers can be matched to the categories of products. This will also allow the OEM to track whether the supplier is really carrying out the work that he has been hired for. This indicates that the greater the ability of the firm to create a match between the categories of suppliers and categories of products, and develop the communication mode for the identified categories of suppliers, the greater the reduction will be in the lead time and the extent of rework.
4. The warranty issues can be traced and solved at the source. The issue of warranty payments to the customer may be decided from the beginning in the contract. In other words, matters that could be the cause of problems can be discussed and settled early enough. The warranty issues allow both the buyer and the supplier to validate that the final customer is not dissatisfied in any way. The contract allows the validation in the sense that it decides the settlement of the claims; in case the specifications (the needs of the customer) are not satisfied. In effect, it can be concluded that the earlier the contract validates the understanding of the warranty issues, the higher the chances are of customer satisfaction as the action to solve customer complaints is immediate.
5. Contracts provide an ideal setting for discussions around the specification. Different issues may be raised and discussed at this point. This allows both the buyer and supplier to understand the specifications, each other's capabilities and

the resources needed to do the job. Every point needs to be validated. For example, if a supplier makes suggestions to the OEM about delivering a new seat, then the OEM will have to draw up a framework to validate that the supplier performs as promised. It is not only validation of the product by the specifications, but also validation of the specifications that is important in outsourced product development. The earlier in the process the contract is used, the better the chances are that the specifications will be satisfied and the product will turn out as planned.

6. The technology level of the suppliers may be analysed before the contract is signed. This would mean the effective exploitation of the suppliers, i.e., both the manufacturing and managerial processes will be taken into account. The technology level of the suppliers has a direct bearing on whether the specification can be satisfied. The validation of the specification with the help of a contract may require the evaluation of the technological level, as certain suppliers may not wish to grow and the technology may be such that it is rapidly changing, for example, in the mobile communications segment. In effect, the earlier the technology level or technology strategy of suppliers is assessed through a contract, the greater the chances are that the specifications can be satisfied to the fullest extent.

8.4 Limitations and Areas for future research

The study is exploratory and qualitative in nature, as the objective is to develop an understanding of the factors that could help improve development between the buyer and suppliers' in the fields of specifications and contracts. The study has its strengths and weaknesses. The strengths lie in the use of the Strauss & Corbin (1990) method for coding qualitative data as it has allowed a certain structuring of the different concepts emerging from the study. Thus, it has led to the proposition of important factors that could help improve development between the buyer and the seller. The weaknesses lie in the fact that the study proposes relationships and interconnections between a limited set of variables in a limited number of companies. Hence, there is a need for testing the relationships and interconnections in a larger sample of companies, so as to observe whether the proposed set of variables holds good in a wider context and also across other industries. While this study has resulted in analytical generalisability, there is a need to quantitatively model some of the selected findings and test them so as to arrive at a statistical generalisability. For example, the use of specification parameters to select and manage suppliers, the use and importance of certain contract elements during entry to the business and during the course of the business. The practical generalisability lies in its application to companies such as in the white goods industry, aircraft industry and in automotive companies in other segments than the case company. The theoretical generalisability or extension to theory has been discussed in Chapter 7.

Future research can be divided into two areas. The first area would be to actually propose the product development process based on specifications. In other words, using the concept of specifications proposed in this work, the development process can be described. The essential difference between the specification approach and the Clark & Fujimoto (1991) approach is that while the former uses specifications to describe the development process the later uses activities and information flow. It was not the aim of this thesis to falsify the Clark & Fujimoto (1991) model, but this research indicates that the product development literature could benefit from a alternative way of describing the development process.

The second area is to test whether the contribution to knowledge holds well in other industries. For example, the aircraft industry has already been examined in this thesis. The external validation of the conclusions needs to be undertaken. By undertaking both quantitative and cross industry studies, the understanding of the role of specifications and contracts can be enhanced. Cross industry studies would provide a complimentary view on the understanding of specifications and contracts. The study of the extent of black box engineering in different industries would prove to be very beneficial as, according to Ward et al (1995), the specifications have yet to be mastered. Once the spread of black box practices in the west has been researched, the specification practices can then be studied with the help of the factors identified in this study. The difficulty or ease of applicability of the factors identified through this study can be recorded so as to enlarge the scope of the existing factors.

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10. APPENDIX 1

DOCUMENTS FROM AUTO OEM THAT WERE REFERRED TO IN THE SUB CASES

The following documents/manuals were used in the sub-cases

• Contracts
• Quality manuals
• VTS specification
• SSTS specification
• CTS specification
• MSS specification
• Auto OEM brand documents
• Job Descriptions
• Project / Line management descriptions
• Auto OEM Today---Internal newspaper
• Minutes of internal meetings
• Object directives
• Request for quotation documents
• Process charts

11. APPENDIX 2
ORGANISATIONAL CHARTS

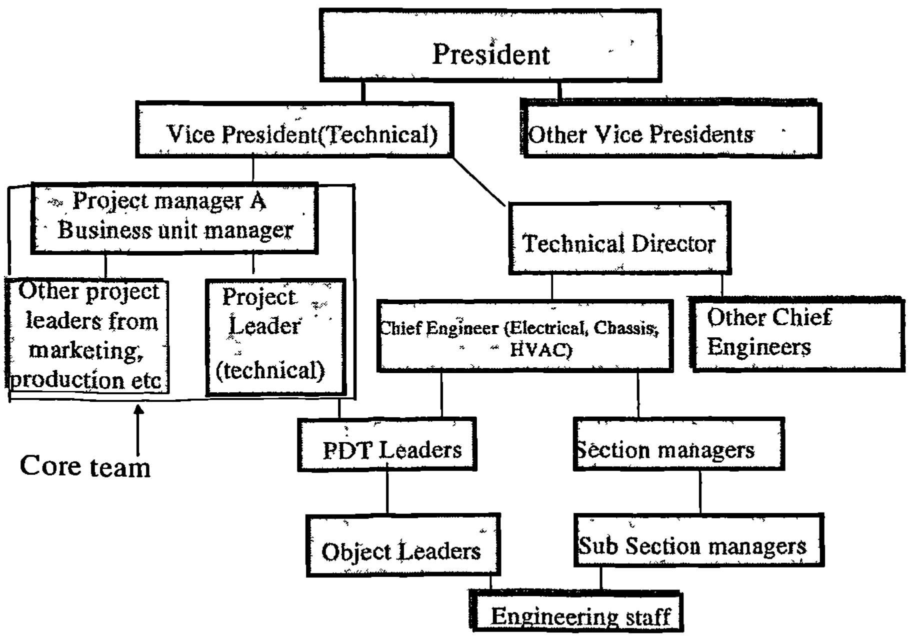

Figure 11-1, The organisation structure at auto OEM

The above Figure 11-1 depicts the organisational structure[137] at the auto OEM. It is a matrix organisation with both a line and a project organisation. In the product development process there exists a program management group. While the product development process describes what to do, when to do it and who will do it, the program management describes the organisation, responsibilities, co-ordination, and decision process for new projects, model changes and minor changes. There is also an important difference between the program management[138] and the line organisation. Demming's "plan do check act cycle" (1982), which is a concept of continuous improvement, can be useful for drawing the line of difference. While the line organisation basically does and acts on the plan, the program management plans and checks whether the plan meets the requirements or not.

The core team

Representatives (also called as project leaders) from the different functions such as purchasing, product engineering, support functions, etc., along with the project

[137] Please refer to Karlsson, C. & Nellore, R., (1998), The Super weight Project Team and Manager, *International Journal of Innovation Management*, Vol.2, No.3, 309-338 for further analysis on the auto OEM structure

[138] Project Management is often referred to as Program Management in the auto OEM

manager, constitute the core team. The main purpose of the core team is to decide when new projects can be started and to solve problems between line and program or in other words, cross-functional problems. Apart from solving problems, it also attempts to strengthen the link between the line and project functions. The program manager has a co-program manager also called the business unit manager. The business unit manager is from the marketing sector and thus provides the program management with a strong commercial touch, in addition to the otherwise technically driven core team. Issues are generally raised at the core team meetings. For example, the marketing representative in the core team would raise the issue of installing a cup holder in the car if deemed necessary from the market.

The PDT team and the object team

The chief engineer for Chassis, Electrical & HVAC has 3 PDT (product development team leaders) leaders (one in chassis, one in electrical and one in HVAC[139]) and 10 line managers reporting to him. Each of these managers have staff and amongst these an object leader[140] who also reports to the PDT leaders. The PDT leaders can have more than one object leader reporting to them.

The object leaders have support functions or object responsibles / object staff from marketing, purchasing, manufacturing, testing, engineering, calculation and design. The object leaders have varied responsibilities and some of them include co-ordination to fulfil targets, to establish relevant time schedules, etc. The object staffs work on all the projects within the company. The company makes no distinction between ongoing and forthcoming projects. The object leaders and staff wear different hats every time they attend different projects. This leads to a split responsibility. This can be explained with a further example. In one project the CD changer was changed few months before the start of production because a particular object staff from the marketing department commented that the CD changer would not sell. The program management immediately made a decision to make the change even though they had worked with the same concept for many months. The object leaders work on projects that are in different stages in the product development process. In case they have a project that is in a critical state before launch, then they

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[139] HVAC stands for heating ventilation air conditioning system and is used in automobiles

[140] An object leader looks after one or more objects like the mechanical and electronic part of the key. It is the smallest element in the system that can be worked on and will vary from organisation to organisation

are more likely to devote more time to it than concentrate on a project which has just started. This could lead to back loading of the project and delays. The object leaders and the PDT leaders have to deal with the suppliers and have to be knowledgeable about the test facilities at the suppliers, for example, testing a radio at the suppliers, etc.

The Figure 11-2[141] below depicts the organisational structure at the aircraft OEM - a matrix organisation as well. The project manager co-ordinates across the different divisions like tactical systems, etc., in order to ensure a finished product/change.

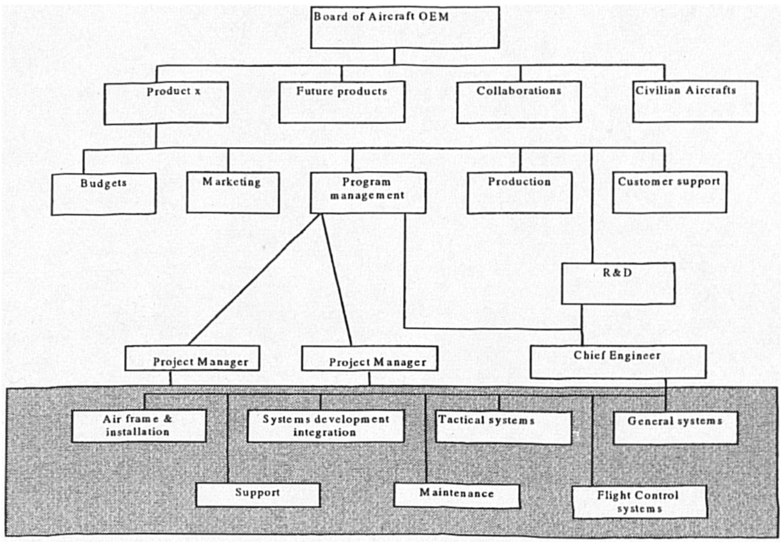

Figure 11-2, The organisation structure at aircraft OEM

[141] Due to the aircraft OEM policy the author will not be able to divulge any more data on the organisation structure

12. APPENDIX 3

INTERVIEW GUIDE

The *pilot studies* were conducted at first. These pilot studies were conducted with twenty-six people and consisted of two open ended questions (following the main research questions) as follows:

- What is the role of specifications in integrated development between the OEM and the suppliers?

Responses: Specifications are a source of problems. Suppliers do not understand specifications. We have a large number of change loops and losses due to specifications.

- What is the role of written contracts in assisting the validation of specifications in the development process?

Responses: Contracts are not functioning as required. They are used as commercial documents and not for obtaining the desired products as stated in the specifications. Suppliers quote low and get their money back at the end. Quality certified suppliers create most problems.

The exploration of these responses together with the literature references lead to the following detailed research questions. In order to answer these detailed questions the author broke down the detailed research questions into further semi structured interview questions for the interviewees. This constituted the ***case study***.

- *What are the different elements that can be contained in a specification?*

  What parameters do the suppliers not understand in the specifications?
  What are the constituents of a specification?
  When do you give the specifications to the suppliers with respect to product development timings?

- *What are the impacts of the network of suppliers on the role of specifications?*
  Are you affected by network of suppliers that your first tier supplier has?
  Can you provide examples where you are aware of which part of the design has been given to the second tier suppliers?
  Can you trace and comment on the flow of design between the OEM and the supplier tiers and the delivery of the component through the supplier tiers and finally to the OEM.

- *What are the issues faced by OEMs with regard to the role of specifications?*
  What are the problems currently faced by the OEM with regards to the role of specification?
  Are these problems supplier related or OEM related or both?
  Can you rank the reasons behind specification problems in order of importance?

- *How can visions for suppliers be created and deployed leading to a positive impact on outsourced product development?*
  Do you have visions for suppliers?
  How can the OEM make its staff understand how to treat the different types of suppliers?

- *What are the possible impacts that the visions for suppliers may have on the core capabilities of an organisation?*
  What impact do you think the visions for suppliers will have on outsourced product development?

- *How could the role of specifications be illustrated with the help of a conceptual model?*
  Can you map the flow of specifications within the OEM?
  Where are the suppliers involved in the specification process?
  How do you ensure that everybody understands the flow of specifications in the organisation?

- *What is the role of contracts in assisting the validation of specifications in the development process?*
  How many contracts do you have?
  Why do you use a contract?
  Are the contracts linked to the specifications?

The above semi structured questions were used as the interview guide during the case study. The responses to the detailed questions on the elements to be contained in a specification and the issues faced with regard to the role of specifications was observed to be one sided and in favour of the OEM. The biased responses made the author inquisitive and send out a questionnaire to the suppliers' (450) and get their opinion on these issues. The questions were as follows:

Dear Supplier,

The Management of auto OEM would be thankful if you could kindly fill in the following questions and return it directly to the sender Rajesh Nellore. This will help improve our relationships by better understanding each other.

- What does the term specification mean to you when considering the activity/function that it is supposed to execute?
- What are the problems faced with regards to the role of specifications?

The vision for suppliers was not observed in any of the visions that were explained to the author by the interviewees. This made the author wonder whether this was characteristic of the entire organisation or just the interviewees. In order to reflect on this a questionnaire was sent to 400 internal employees from a cross section of departments in order to get their opinion on the visions that guided their work. Further, it would be helpful to find out from their responses whether the visions for suppliers existed within the company. The questions that was asked is as follows:

- What is the vision guiding your developmental work?

The case study combined with the inputs from the internal and external questionnaire led to the ***supplementary interviews*** at the aircraft OEM as follows:

- *What is the role of contracts in assisting the validation of specifications in the development process?*

13. APPENDIX 4
AN OVERVIEW OF THE AUTOMOTIVE INDUSTRY

The Automotive Industry - A Consolidating Industry

Over the last five years, the automotive industry has consolidated very quickly. Intense mergers and acquisitions have taken place within the OEMs as well as in the component (supply) industry. This has been followed by other trends such as modularisation and web based trading.

The OEMs

The automobile industry is seeing an accelerated concentration movement. This is in various forms such as mergers and acquisitions (Volvo and Land Rover by Ford), minority take-over (Mitsubishi by DiamlerChrysler), crossed participation (Volvo - RVI), etc. The concentration rate has increased substantially in the last three years with the merger between Daimler and Chrysler, the deal between Fiat and GM; the acquisition of Nissan, Dacia and Samsung by Renault; and the acquisition of Volvo and Land Rover by Ford Motor Company. Table 13-1 shows the eight dominant auto OEM groups and manufacturers in 1999.

RANK	GROUPS	PRODUCTION 1999	SHARE
1	GM-ISUZU-FUJI-SUZUKI-FIAT	13,016	23.81%
2	FORD-MAZDA-VOLVO-JAGUAR-LAND ROVER+DAEWOO	9,010	16.48%
3	DAIMLERCHRYSLER-MITSUBISHI-HYUNDAI-KIA	7,620	13.94%
4	TOYOTA-DAIHATSU+HINO	5,110	9.35%
5	VW-AUDI-SEAT-SKODA	4,840	8.86%
6	RENAULT-NISSAN-SAMSUNG-DACIA	4,630	8.47%
7	PSA	2,500	4.57%
8	HONDA	2,380	4.35%
	TOTAL	**54,658**	

Table 13-1, Automotive group rankings (Source: Chanaron, J. J, 2000)

Not all car makers have engaged in the concentration trend. Toyota, Honda and PSA prefer internal growth so as to enlarge their international presence. It is interesting to note the differing strategies of the two French car makers. Renault has multiplied its international mergers and acquisitions, thus, increased its size considerably and rapidly, while PSA has defended its status as an independent car maker. PSA prefers to rely on its localised co-operation with diversified competitors-partners so as to benefit from economies of scale. Moreover, international presence does not always bring large rewards. BMW has failed with its acquisition of Rover in the United Kingdom. General Motors and Ford are generating most of their profits from their North American Operations while the European Operations are running at loss and or minimal returns.

The component industry

There is tremendous pressure on the automotive OEMs to produce quality products faster. According to Chanaron (2000), development times have been reduced to a low of 24-30 months from the 7-8 years that was characteristic of the 60's and 70's. The following figure (13-1) illustrates this.

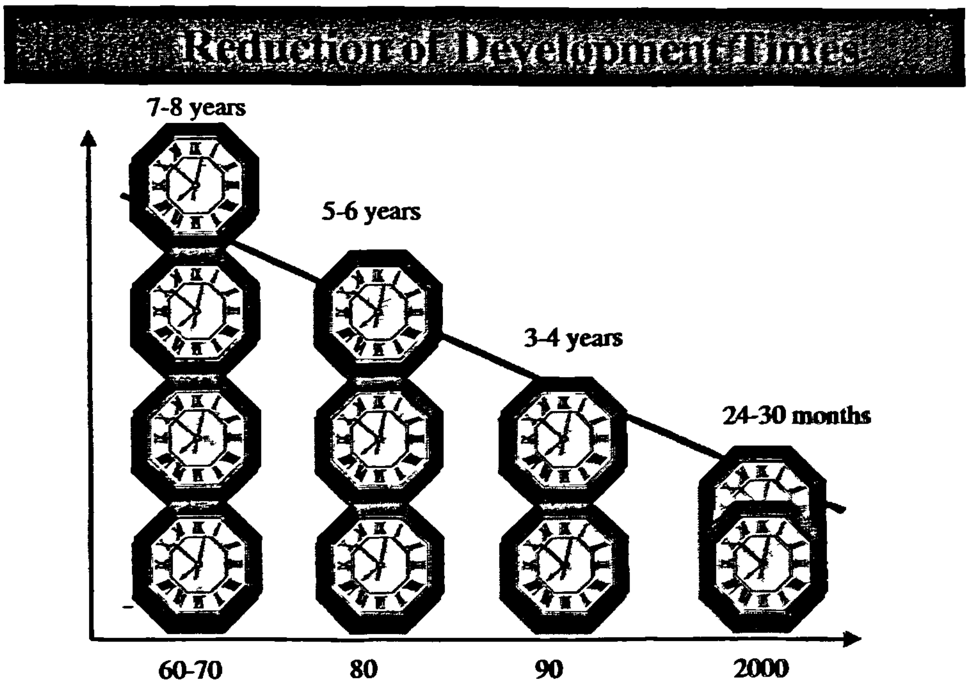

Figure 13-1 , Reduction of developmental times

In this context, OEMs have come to realise that they cannot concentrate on all areas in the automobile and in order to meet the short development times they need to solicit the help of their suppliers. This means that the expectations on the suppliers have changed from supply of simple parts to co-development of complex systems. Buyer supplier relationships have also changed, accompanying this trend best explained by Lamming (1993).

He conceptualises four phases of buyer supplier relations in the automotive industry, namely the traditional phase (before 1975), the stress phase (1972-1985), the resolved phase (1982 onwards) and partnership phase (1990 onwards). In the traditional phase, sourcing was mostly price based with the lowest bid getting the orders. But inefficiencies related to seeing price negotiations as a win/lose game (Lamming, 1993, p. 158) hampered long-term productivity. The stress model was generated by Western carmakers' fear for survival, and resulted in strong pressure on suppliers to reduce costs, as competition was still price-based. During the stress phase, the inefficiencies of the traditional model were exposed and performance worsened (Lamming, 1993, p. 160.) In the resolved phase factors such as quality and delivery were being considered along with price in making the sourcing decisions. In the partnership phase, sourcing decisions were based on an added number of factors such as the performance history of the suppliers, collaboration, and extensive exchange of information between the buyer and the supplier.

This increased supplier involvement is visible in the automotive industry. Burt (2000) elucidates that the global value of the parts sector has risen to more than US$950bn from US$450bn in the past ten years with a supplier base shrinking from 13,000 to 8,000 suppliers. The most recent Financial Times survey on the tire industry (FT, 2000) estimated the total turnover at US$70bn in 1999. The average size of the top 25 first tier suppliers has grown significantly between 1992 and 1999, from US$ 4.7bn in 1992 to 6.5 in 1995 (Ernst & Young, 1999) and 10.3 in 1999 (table 13-2).

Name	Rank 1999	Turnover 1999 US$bn	*Turnover 1994* US$bn	Rank 1994	Δ/year %
DELPHI	1	29,20	24,00	1	4,0
VISTEON	2	19,40	5,45	10	28,9
BRIDGESTONE	3	17,10	16,11	2	1,2
BOSCH	4	16,29	12,16	3	6,0
DENSO	5	14,50	10,36	5	6,9
MICHELIN	6	13,80	11,90	4	3,0
DANA	7	13,20	4,73	11	22,8
GOODYEAR	8	12,90	9,45	6	6,4
LEAR	9	12,40	2,86	>25	34,1
JOHNSON CONTROLS	10	12,10	2,75	>25	34,5
ATECS	11	12,00	4,18	17	23,5
TRW	12	11,30	5,91	8	13,8
ZF	13	9,50	4,12	18	18,2
CONTINENTAL	14	9,13	6,14	7	8,3
MAGNA INTERNATIONAL	15	8,40	2,64	>25	26,0
VALEO	16	7,70	4,19	16	12,9
AISIN SEIKI	17	7,50	5,73	9	5,5
ARVINMERITOR (*)	18	7,50	3,64	20	4,4
FEDERAL MOGUL	19	6,50	1,80	>25	29,3
YASAKI	20	6,40	4,26	16	8,5
THYSSEN-KRUPP	21	5,70	4,12	19	6,7
DUPONT	22	5,00	4,18	17	3,6
FAURECIA	23	4,26	3,60	>25	3,4
EATON	24	4,20	2,91	>25	7,6
PIRELLI	25	4,11	4,55	13	-2,0
MAGNETI MARELLI	26	4,10	3,43	22	3,6
GKN	27	4,09	2,62	>25	9,3
SIEMENS	28	3,82	2,43	>25	9,4
AUTOLIV	29	3,81	1,63	>25	18,6
FREUDENBERG-NOK	30	3,80	n.d.	>25	n.d.
CUMMINS	31	3,20	2,37	>25	6,2
TOTAL WORLD PART INDUSTRY		950,00	654,00		
TOTAL WORLD TIRE INDUSTRY		70,00	61,00		
TOTAL		**1 020,00**	**715,00**		
TOTAL TOP 10		160,89	99,79		
TOTAL TOP 20		253,52	147,05		
TOTAL TOP 25		274,69	165,18		
SHARE OF TOP 10		**15,77%**	**13,96%**		
SHARE OF TOP 20		**24,86%**	**20,57%**		
SHARE OF TOP 25		**26,93%**	**23,10%**		

Sources: Annual reports on Internet ; Barnérias, de Banville, Chanaron, Deranlot (1997). (*) Pro forma after the merger in July 2000.

Table 13-2, Ranking of global suppliers

According to 1999 figures, the share of the top 20 global suppliers in the total world part industry has grown from 20.6% to 24.9% over the last five years. Very large and well-known companies such as ITT Automotive and B.T.R. have disappeared or sold out their automotive divisions. Some have emerged as global players: Magna jumped from rank 31 to 15 and Federal Mogul from a very low ranking to rank 18 through mergers and acquisitions.

Modularity

Practitioners and academics alike are paying increased attention to an increasingly important strategic question, namely the dynamics of modular product development wherein suppliers have responsibility for modularity (Sako & Murray, 1999). Modularization and outsourcing are increasingly presented as the future means of progress for the automotive industry Hatzfeld (2000). The modular approach or modularity is a special form of product design that creates a high degree of independence or "loose coupling" between component designs by standardising component interface specifications (Sanchez et al, 1996). This "loose coupling" between components can be incorporated in the design stage itself or it can be incorporated in the assembly process. In essence, modularity can be seen as covering both the development process – modular development, and the assembly process – modular assembly. Both modular development and modular assembly do not necessarily have to be done by OEMs themselves, rather suppliers can be involved as well (Baldwin et al, 1997). This means that modularity can be engaged in by the suppliers, by the OEM's and jointly between the OEM and the suppliers.

Scania[142], the Swedish truck manufacturer is an example of a firm that has a design process that is modular, i.e., they have only one variant of the main cab with optional attachments that could suit the diverging cab requirements of their final consumers. Other manufacturers that do not incorporate modular designs have multiple variants, sometimes in excess of six main cabs like Volvo, and Mercedes Benz. Modular assembly is one where groups of parts or components are sub assembled off line and then supplied to the automotive plant where they are installed with other sub assemblies as a complete unit (Robertson & Ulrich, 1998). For example, the cockpit

[142] Scania is controlled jointly by Volkswagen, Volvo AB and Investor AB

of the Mercedes Benz M class car is delivered as a single unit as opposed to many different parts and components.

Giving suppliers responsibility for modules will allow the manufacturers to escape the problems associated with managing a huge system directly and instead the suppliers would be responsible for the modules (Baldwin et al, 1997). Modularity has many benefits, some of which can be described as follows (Baldwin et al,1997; Feitzinger et al, 1997; Garud and Kumaraswamy, 1993; Gilmore et al, 1997; and Sanchez et al, 1996):

- Maximise the number of standard parts
- Reducing complexity in the design of goods and services
- Manufacture different modules at the same time
- Early diagnosis and isolation of potential quality problems
- Proving strategic flexibility to allow a raid response to changing markets and technologies created by product variations
- Modular components can be substituted without having to redesign other components
- Postponement of the task of differentiation until the last possible point in the supply network
- Different companies can produce different modules in the overall product

These benefits have led many firms to adopt extensive outsourced modularity within their design and assembly processes. Some examples of firms engaging in assembly modularity are the Volkswagen's truck plant in Resende, Brazil, General Motors Blue Macaw Plant in Gravatai, Brazil, DiamlerChrysler's Smart Car plant in Hambach, France and Dakota plant in Curitiba, Brazil and the Ford Amazon plant in Camacari, Brazil. However, not all firms share the same enthusiasm in outsourcing modularity. The widely known "world class" company namely, Toyota is yet to adopt outsourcing the modular approach either in design or in assembly. Even though Toyota has not outsourced modularity, it has still posted impressive economic and financial results, often better than its rivals have. Other Japanese companies such as Honda also share this bias against outsourcing modularity. In between these extremes lie companies such as Renault - Nissan Motor Manufacturing (France and Japan) and PSA (Peugeot - Citroen, France) who have a "wait and see approach". In other words, they are neither in favour of outsourcing modularity nor against it.

Moves towards web based trading

As pointed out in a survey carried out by KPMG Consulting (1999) on Global Supply Chain Benchmarking and Best Practices in 1999, IT, and in particular web-based technology, is identified as another significant challenge over the next 10 years in the automotive industry. Ernst & Young (1999) pointed out that 25 to 30% of the cost of a car has to do with inefficiencies in the way the supply chain manufactures and supplies a car (Sage, 1999).

E-business is currently considered as one of the most promising drivers for change in the automotive industry, and in particular in its value added chain from R&D and design to the final customer. According to the most enthusiastic observers, it will completely revolutionise the system. Schlott (2000) compares the Internet revolution to the fashion for just-in-time and lean philosophies in the early 1990's. For the most cautious, it will simply be one more supply and sales channel in addition to the already existing and more traditional ones (Licoppe, 2000). According to Lamm (2000), the Internet is not creating a frontal competition with the "old" system, but is adding a new tool, which is challenging it and requiring its complete reshaping. From an academic point of view, in-depth research is still to be conducted in order to establish some more stabilised models before any robust managerial recommendations can be formulated.

E-business is concerned with three different channels Chanaron (2000):

- Business-to-business (B2B) between OEMs and their suppliers and between tier-one and tier-two suppliers;
- Business-to-business between OEMs and their dealers and other distributors;
- Business to customers (B2C) between OEMs and distribution networks and their final customers.

So far, e-commerce is still emerging and at an unexpected speed. But market research shows that e-B2B is growing much faster than e-B2C. Forrester Research reports that 75% of spending through the Internet results from the business-to-business segment and predicts that it will represent total purchases of US$183bn by 2001 (Mann, 1999). The total B2B e-commerce in the US is estimated at US$2,700bn by 2004 of which 53% will flow through e-marketplaces (Forrester website)[143]. Wolffe, Tait & Bowe (2000) estimate that 900 online exchange systems will be established in the very near future. Deloitte Consulting (Sengès, 2000) pinpointed that by the end of 2000, 91% of North American corporations will buy through the Internet against 31% in May 2000. Kleinbard (2000) quotes a survey by Keenan, an Internet analyst, which shows that out of 620 B2B Web sites, only 10% were active, i.e. processing real transactions, in May 2000.

Huge online B2B marketplaces are on their way. Within the automotive industry, there are Covisint, under the leadership of the major OEMs (Ford, GM, DaimlerChrysler, Renault, Nissan and Toyota), and Rubbernetwork in the tire industry. Electricity power suppliers and steel companies (MetalSite) are also struggling to organise themselves into integrated online exchange systems (Wolffe et al, 2000).

Many different tasks could be performed through the Internet (table 13-3). But only a few systems, such as IBM *Websphere* and Oracle *E-Business Suite* offer a wide choice of operations.

Auction/Bidding	Real-time Purchasing Accounting
Online Price Quoting	On-line early warning of quality and logistics problems
Production Specification/Information	Budgeting, Planning and Scheduling
Order Management & Tracking Follow-up	Marketing & Business Intelligence
Invoicing and Accounting	Human Resources Management and Payroll
Inventory and surplus management	Training
Project Management & Meeting Planning	Data Interchange

Table 13-3, Potential purchasing related tasks to be performed on line

[143] According to IBM, in 2000, B2B will account for 78% of the total revenue generated by e-commerce.

One of the key advantages of e-commerce is indeed to manage all services related to purchasing such as quality, warranty, inventory, deliveries, invoicing, etc. Therefore, the development of e-B2B is likely to lead to a decrease in the usage of Electronic Data Interchange (EDI), if not simply to a complete replacement of EDI by the Internet.

14. APPENDIX 5

The open coding technique

Introduction

The open coding technique (Strauss & Corbin, 1990) was utilised in analysing the questionnaires. Open coding is the part of the analysis that represents the naming and categorisation of phenomena through close examination of data (Strauss & Corbin, 1990).

In the open coding technique, the following steps are followed:

- The data is broken down into discrete parts
- The data is closely examined, compared for similarities and differences
- And questions are asked about the phenomena reflected in the data.

The making of comparisons and the asking of questions are the two analytic procedures that are basic to the coding process. In the open coding procedure, the data is broken down by taking apart a sentence or an observation and giving each incident a name (conceptual label) which stands for or represents a phenomenon. These labels are compared for similarities and dissimilarities and similar phenomena are regrouped to form a category. This is done to reduce the number of units that the researchers have to work with. The process of regrouping similar phenomena is called categorising. The names for the concepts that are chosen are usually the ones that are related logically to the data (Strauss & Corbin, 1990).

The open coding technique that was utilised for the questionnaires is detailed above. I will show the coding procedure in the following paragraphs. The coding has been performed by a focus group of three professors and twelve managers[144] from the industry. The grouping of parameters and creation of categories was performed by the focus group. The author was a part of the focus group as well.

[144] The twelve managers consisted of both managers from suppliers companies (6) and managers from the auto OEM (6). By having managers from both the sides, possible biases were minimised. Having three other professors' work with the focus group further reduced bias. The panel were given the responses and asked to categorise similar phenomena i.e. follow the open coding technique.

Chapter 5: Detailed question 1, Elements in a specification

An open-ended question was asked in the questionnaire namely **"What does the term specification mean to you when considering the activity/function that it is expected to execute?"** The responses are tabulated as below (Table 14-1) along with the response rates from the suppliers.

ID	What does the term specification mean to you?	% of Suppliers mentioning
1	Requirements of the customer/user that the product has to fulfil	56%
2	A very detailed description of a product or a process	52%
3	Technical description of products and processes which may contain drawings.	50%
4	Norms which specify several characteristics of the part/system etc. to be fulfilled in order to guarantee the good function and working of the part and of course in order to meet customer requirements.	45%
5	The specifications are a preliminary product performance requirement that allows the product to meet and survive satisfactorily "in use."	42%
6	Specifications are the description of a product and its properties as well as the methods of obtaining it. The methods could include details about the level of technology involved.	34%
7	Specifications are the summary of all important data, limits, methods, performance, targets, etc. Some of these parameters may be in the form of drawings.	32%
8	Defines the product properties that are necessary or will be measured.	31%
9	Specifications are technical regulations and drawings	26%
10	Specifications are the requirements to meet the function	20%
11	To manufacture in accordance with the customer requirement.	18%
12	Specification is a vehicle for common understanding of requirements.	15%
13	Any written communication is a specification	14%
14	Description of process operations and acceptance standards	10%

Table 14-1, Meaning of a specification

There are 14 responses in the above table. However, there were 450 questionnaires that were distributed and a 54% response rate was obtained. It is obvious that not all suppliers would have given the same response in terms of wording. Since it was not possible to have all the responses as individual IDs (responses could have reflected the same data), the advice of Strauss & Corbin (1990) was followed. I will take an example to show how the response ID1 was generated.

The responses that were obtained for the open ended question on **"What does the term specification mean to you when considering the activity/function that it is expected to execute?"** (Control area ID1) was as follows:

1. Requirements that the product has to fulfil for the customer
2. Requirements of the customer to fulfil
3. OEM wants us to do something and we do it
4. We need to satisfy the product requirements requested by the buyer

I will examine each response and identify commonalties. The first response talks about the customer requirements that the product has to fulfil. The second response coveys the same meaning. The third response talks about the requirements of the OEM and the fourth response conveys the same meaning as the third response. The OEM is the user of the supplier goods and hence OEM requirements could mean the final user requirements or the OEM requirements. It is appropriate to consider both the statements. The central message from the above is satisfaction of product requirements of the customer and the user and hence can be written as below:

ID1: Requirements of the customer/user that the product has to fulfil

By examining the responses, labels[145] are assigned to each response as follows (Table 14-2):

[145] These labels closely reflect the phenomena in each response.

ID	What does the term specification mean to you?	Labels
1	Requirements of the customer/user that the product has to fulfil	Com, stn, cr
2	A very detailed description of a product or a process	Com, pr, fun, pror
3	Technical description of products and processes which may contain drawings.	Com, fun, stn, dra
4	Norms which specify several characteristics of the part/system etc. to be fulfilled in order to guarantee the good function and working of the part and of course in order to meet customer requirements.	Com, pr, fun,cr
5	The specifications are a preliminary product performance requirement that allows the product to meet and survive satisfactorily "in use."	Com, pr,
6	Specifications are the description of a product and its properties as well as the methods of obtaining it. The methods could include details about the level of technology involved.	Com, pr, pror, lt
7	Specifications are the summary of all important data, limits, methods, performance, targets, etc. Some of these parameters may be in the form of drawings.	Com, dra, pror, pr,
8	Defines the product properties that are necessary or will be measured.	Com, pr, pror,
9	Specifications are technical regulations and drawings	Com, stn, dra
10	Specifications are the requirements to meet the function	Com, pr, fun, pror
11	To manufacture in accordance with the customer requirement.	Com, fun
12	Specification is a vehicle for common understanding of requirements.	Com, pr, pror, cr
13	Any written communication is a specification	Com, fun
14	Description of process operations and acceptance standards	Com, stn

Table 14-2, Labelling

Labels are logically related to the data. The labels are examined with each other for similarities and dissimilarities and then regrouped as follows (Table 14-3)

Category	Labels	area
Communication	Com	Transversal
Product Requirements	pr	1,2,4,5,6,7,8,10, 12
Functionality	fun	2,3,4,7,10,11,13
Process Requirements	pror	2,6,7,8,10, 12
Standards	stn	1,3,7,9,14
Drawings	dra	3,7,9
Customer Requirements	cr	1,4, 12
Level of Technology	lt	6

Table 14-3, Regrouped parameters

It is observed that communication is a transversal variable affecting all the categories. The categories are arranged in decreasing order of importance.

Chapter 5, Detailed question 2, Issues in the specifications

The suppliers were asked an open-ended questionnaire "**What are the issues faced with regard to the role of specifications?**" The responses are tabulated below (Table 14-4) along with the response rates.

ID	Issues	% of Suppliers Mentioning
1	Specific requirements often lead to specific versions. There is not enough standardisation, which increases cost.	10%
2	Sometimes there is no cost optimisation	32%
3	Sometimes the specifications are too general and do not cover the requirements of the part in question.	23%
4	The OEM does not give reasons for changes in specifications to the supplier.	35%
5	Even when it is very urgent, some specifications are missing such as tolerances and dimensions.	15%
6	There are problems in interpretation of specifications as well as in language translations.	49%
7	Specifications keep changing all the time. • Specifications are even changed after tooling and method of manufacture have been decided.	52% 28%
8	Sometimes the specifications are gold plated. There are a lot of opportunities to add more costs.	15%
9	OEMs do not listen enough to the expertise of suppliers. For example too much cost saving in the design might lead to poor satisfaction of functionality in several cases.	29%
10	There are extremely short lead times.	22%
11	There is a lot of over specification which increases the cost. For example : • The tolerances are too narrow • Some of the criteria are well beyond the life usage of the product	35% 15% 20%
12	New specifications are not discussed in the planning stage	16%

Table 14-4, Issues identified through the survey

The are 12 responses in the above table. It is obvious that not all suppliers would have given the same response in terms of wording. Since it was not possible to have all the responses as individual IDs (responses could have reflected the same data), the advice of Strauss & Corbin (1990) was followed. I will take an example to show how the response ID4 was generated.

The responses that were obtained for the open ended question on **"What are the issues faced with regard to the role of specifications"** (Control area ID4) were as follows:

1. The OEM changes the specification without informing us
2. The specifications are rapidly changing all the time
3. Why do specifications have to change?
4. How do we understand the reasons behind the changes in the specification?

I will examine each response and identify commonalties. The first response informs that the OEM does not give reasons as to why the specifications were changed. The second response conveys the fact that the specifications are changing all the time. Because the suppliers make this comment, it appears that they are not aware of why the specifications are changing. The third response concerns the reasons for changes in specifications. The fourth response conveys the same meaning. In summary it can be said that the OEM does not inform the supplier as to why it changes the specification.

ID4: The OEM does not give reasons for changes in specifications to the supplier

By analysing the responses in the questionnaires labels[146] are attached to the responses (Table 14-5):

ID	Issue Area	labels
1	Specific requirements often lead to specific versions. There is not enough standardisation, which increases cost.	Lt, tc
2	Sometimes there is no cost optimisation	Lt, ct
3	Sometimes the specifications are too general and do not cover the requirements of the part in question.	Lt, tc
4	The OEM does not give reasons for changes in specifications to the supplier.	Lt, cs
5	Even when it is very urgent, some specifications are missing such as tolerances and dimensions.	Lt, tc
6	There are problems in interpretation of specifications as well as in language translations.	Lt, iu
7	Specifications keep changing all the time. • Specifications are even changed after tooling and method of manufacture have been decided.	Lt, cs
8	Sometimes the specifications are gold plated. There are a lot of opportunities to add more costs.	Lt, ct
9	OEMs do not listen enough to the expertise of suppliers. For example too much cost saving in the design might lead to poor satisfaction of functionality in several cases.	Lt, psd
10	There are extremely short lead times.	Lt
11	There is a lot of over specification which increases the cost. For example : • The tolerances are too narrow • Some of the criteria are well beyond the life usage of the product	Lt, tc
12	New specifications are not discussed in the planning stage	Lt, psd

Table 14-5, Labelling

The labels were compared with each other and resulted in the categorisation as in Table 14-6. Item 10 in the above table-short lead-time- is a transversal factor influencing all of the above categories. The categories are arranged in decreasing order of importance.

146 The labels closely reflect the phenomena in the responses.

Category	Labels	Area
Lead Time	Lt	Transversal
Technical Content – Level of detail in requirements	Tc	1,3,5,8,11
Changes of Specifications	cs	4,7
Cost	ct	2,8
Participation of the suppliers in the specification process	psd	9,12
Interpretation and Understanding	iu	6

Table 14-6, Regrouped parameters

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15. APPENDIX 6 GLOSSARY OF TERMS

1. OEM:	It stands for Original Equipment Manufacturers like Electrolux, Scania, Ford, etc. There are the final assemblers that present the final product for customer sales.
2. P&L:	It stands for the noted Paris machine tool company Panhard et Levassor.
3. GM:	It stands for General Motors Corporation headquartered in Detroit, United States.
4. Supply Network:	Hakansson (1987) has conceptualised the key elements of networks as consisting of actors, resources and activities. However, their work has provided little guidance on supplier network strategies (Harland, 1996). Harland (1996) elucidates that supplier networks include aspects related to more than one player and the interaction between players. Each focal organisation has its own network; this network comprises of its own unique set of actors, resources and activities, which together constitute its identity (Gadde & Hakansson, 1993). Hakansson & Snehota (1995) elucidate that the position of a company with respect to others reflects its capacity to provide value to to others (innovativeness, productiveness). Harland (1996) further explains that as an organisation decides to reposition itself it changes its identity.
5. Tiers	Shimokawa (1985) describes a pyramidal supply system in the automotive industry as encompassing several tiers and supplying to OEM/s who are located at the apex of the pyramid. The automotive firms are supplied by the first tier suppliers who in turn are supplied by the 2nd tier suppliers and so on. Hines (1994) elucidates that the assemblers must look after the welfare of the 1st tier suppliers who in turn need to look after the welfare of the 2nd tier suppliers and so on. Since the 1st tier suppliers often supply more than one industry sector Lamming (1993) has termed the 1st tier supplier as one that often has a significant technical influence on the assembler even though some percentage of its sales are through an intermediary sub assembler.
6.Collaboration:	Collaboration does not imply some form of lifetime commitment or total openness and trust (Burnes & New, 1997). It implies a mutual dependency but the extent of both the parties (buyer - supplier) benefiting need not be the same. The main difference between partnership and collaboration is that while the former requires assumptions about commitment and mutual dependency, collaboration can be worked out at a matter of fact level without the need for organisational posturing.

Authors ↓	Define specifications	Types of specifications	Requirements of specifications	Models of specifications	Capabilities for specifications	Expertise effects on specifications	Customer benefits	Technology effects	Type of supplier	Trade offs	Traps	Communications	Creation of common goal
Smith & Reinartsen	*	*					*			*	*		*
Hollins & Pugh	*												
Elliot	*												
Haslam		*											
Hollins & Hurst		*					*						
Roozenburg & Dorst	*		*										
Fine & Whitney			*			*		*					
Smith & Rhodes				*									
Iansiti				*									
Wheelwright & Clark					*							*	
Schein						*							
Schrader						*							
Clark						*							
Ward				*					*				
Karlson												*	
Aoshima								*					
Kamath & Liker									*				
Cusumano									*				
Rosenau											*		
Söderquist												*	
Clark & Fujimoto												*	
Karlsson et al													*
Burnes & New													*
# times mentioned	4	3	2	3	1	4	2	2	3	1	2	4	3

16. APPENDIX 7 THE SPECIFICATION LITERATURE STRUCTURE

Authors	Contract Contents	Reciprocal dependence between specifications and contracts	Use of contracts
Lamming	*		
Kolay	*		
Monszka	*		
Cash	*		
Harrison	*		
Hyun	*		
LaLonde et al	*		
Turnbull et al	*		
Larson	*		
Levy et al	*		
Mohanty et al	*		
Kaulio		*	
Major & Taylor			*
Asmus & Griffin			*
Cooper			*
Harris et al			*
# times mentioned	11	1	4

17. APPENDIX 8 THE CONTRACT LITERATURE STRUCTURE

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USING PORTFOLIO APPROACHES TO MANAGE ENGINEERING-PURCHASING-SUPPLIER INTERACTION*

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New product development is large-scale problem solving [12] consisting of thousands or even tens of thousands of tasks that must be woven into a complex network of relationships [14]. The problem-solving process and the tasks are not fulfilled by individuals but need to be partitioned between individuals and firms [14]. This partitioning of tasks [12] is challenging, as the companies must take advantage of each other's domain of expertise. To aid in this process, many authors [2, 7, 11] have suggested using portfolio models as a means of splitting products into distinct categories. Using these categories leads to the partitioning of tasks and in this particular case, products that are compatible with the supplier's capabilities. Although there are certain criticisms against portfolio models (e.g., the different dimensions used in the model are only approximate estimations of the parameters that are supposed to be measured), they have gained importance in many organizations around the world. This article is intended to help companies and readers who have already adopted the portfolio model despite the criticisms against it.

Portfolio models facilitate the buyer–supplier interaction. This is important as collaboration is the preferred route to product development [3] considering the ever-increasing costs, shorter product lead times, internationalization of markets, technological convergence, and so on. The benefits of collaboration were reflected in a poll conducted by *Business Week* [4], which showed that more than half the purchasing managers responding were more likely to outsource than insource. The survey also indicated that it was easier to closely control quality when an item was outsourced than when it was insourced. Given this background, it is important for an organization to develop a clear process of involving suppliers. Their involvement is contingent on the quality of the interaction between purchasing and engineering.

*The views expressed here are solely those of the authors and do not necessarily represent General Motors policies/procedures.

In the following section we present a theoretical review of pertinent literature. Next we present data collected and describe the methodology used. Finally, we present conclusions and managerial implications.

PORTFOLIO MODELS AND SUPPLIER CATEGORIES

Portfolio models divide components/systems into different categories. Fiocca [5] identified four product categories, which Olsen and Ellram [11] expanded on and termed *strategic products, bottleneck products, leverage products,* and *noncritical products* (fig. 1). These classifications are based on the difficulty of managing the purchasing situation and the strategic importance of the project. The difficulty of managing purchasing can be measured by parameters such as the power of the suppliers and the number of available suppliers. The strategic importance of the project can be measured by volume of purchase and value of purchase.

Drawing on Fiocca's [5] model, Olsen and Ellram [11] further operationalize the product categories by classifying the supplier relationships based on the at-

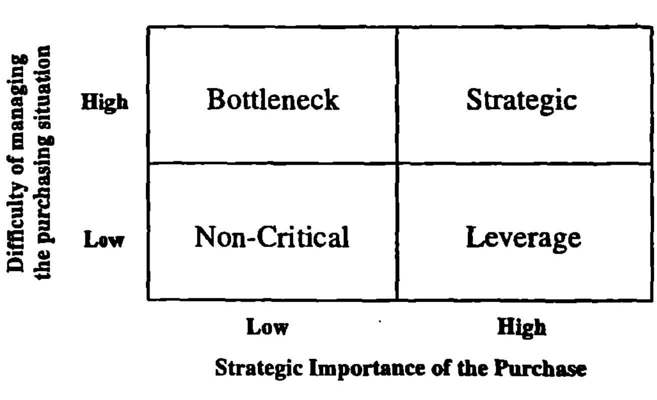

FIGURE 1: Product categories

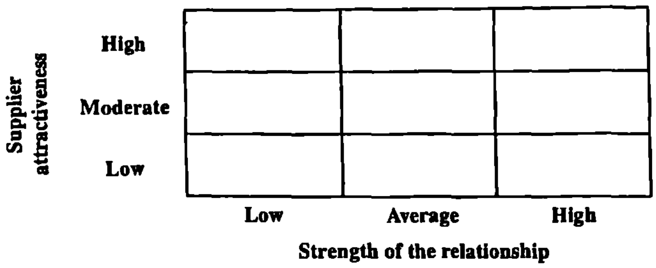

FIGURE 2: Analysis of supplier relationships*

**This figure demonstrates that the different types of components require different types of supplier attractiveness and strength of relationship.*

tractiveness of the supplier and the strength of the relationship. Two parameters used to measure supplier attractiveness are supplier margins and supplier design capabilities. Volumes of purchase and technical cooperation are used to measure the strength of the relationship with the supplier. Figure 2 illustrates that the four identified product categories may require certain strength of relationship and supplier attractiveness to be realized.

Kamath and Liker [6] include the importance of classifying suppliers as well. The four supplier classifications are *partner, mature, child,* and *contractual*. The key attributes of each can be summarized as follows:

- Partners, at the top of the hierarchy, develop entire subsystems and collaborate while specifications are being set.
- Mature suppliers are similar to partners as they too design complex assemblies, although the original equipment manufacturer (OEM) gives them the critical specifications.
- Child suppliers design simple assemblies to the detailed specification of the assembler.
- Contractual suppliers develop and manufacture standard products that can be ordered from a catalog.

The relationship between the different types of suppliers and the OEM have been described in terms of the interface between them [1]. The type of interface used will have direct consequences on the way the supplier's resources are activated [1]. This argument can also be extended to the type and quality of the interface used between engineering and purchasing within a firm. Araujo et al. [1] propose four interfaces: the *standardized*, the *specified*, the *translation*, and the *interactive*. The standardized interface corresponds to contractual suppliers, the specified interface to child suppliers, the translation interface to mature suppliers, and the interactive interface to partner suppliers. Although Araujo et al. [1] do not acknowledge the contributions of Kamath and Liker [6], the characteristics of the interfaces described are exactly the same. For example, Araujo et al. [1] state that in a specified interface the suppliers are given precise directions by the OEM. Kamath and Liker [6] have not named the interface but say that child suppliers require detailed specifications from the OEM. A further example would be the translation interface in which directions are given to the supplier based on the context and functionality required. This, according to Kamath and Liker [6], is a mature supplier who requires rough specifications from the OEM to commence work.

The portfolio models and supplier categories described above were given to a focus group of engineers and purchasers. When asked to work with these models and try to apply them in real situations, respondents said they could not understand the models in the context of the entire development process. That response prompted an examination of the connection between the models.

EXPLORING THE CASE COMPANY

Currently engineers within the case company identify a need either on their own or based on market needs given to them through a project directive. They decide on the preliminary specifications of the component/system under consideration along with other members of the development group they belong to. The group, which consists of members from purchasing, engineering, after sales, manufacturing, marketing, and brand, evaluates the component/system and specifies the functionality requirements. Then the purchasing representative is tasked to bring in one or more suppliers to satisfy the need. Although the purchaser is a part of the development group, he or she has little input until the engineers agree to the functionality specification. Occasionally the engineers may start work with a supplier without informing the purchasing department and later on in the process instruct the purchasing department to contract the particular supplier. This leads to frustration in purchasing due to lack of full involvement. Basically, the current process can be described as supplier involvement once the engineers have decided on the functionality specification. The supplier is selected to satisfy a need projected by engineering.

METHODOLOGY

A case study approach was used to conduct the exploratory research. Data were collected primarily through interviews, participant observation, and archival sources. Four in-depth case studies were conducted involving one automotive OEM and three supplier firms based in Europe. Altogether 40 interviews were conducted for this article. Those interviewed included the vice presidents of engineering and purchasing, senior buyers and engineers, managers, and chief engineers, both at the suppliers and at the OEM. Archival documentation reviewed included feasibility studies, reports, memos, minutes of meetings, proposals, newspaper articles, and books. These documents were collected and analyzed to identify and/or validate data.

Data from interviews and observations were analyzed according to the open coding technique [13]: Data are first broken down by an observation, a sentence, or a paragraph, then regrouped in categories that pull together groups of ideas and events that become subcategories. To improve reliability [15], data from interviews, open discussions, and observations are recorded in three forms:

- Field notes taken directly from interviews and observations
- Expanded notes typed as soon as possible after the field work is done, including comments on problems and ideas that arise during each stage of the field work (to be used as a guide for further research)
- Running record of analysis and interpretation (open coding and axial coding)

Establishing a chain of evidence ensured by these documents improved validity [15]. Further, because each case study relied on documents, semistructured interviews, and observations, multiple measures of the same phenomenon were provided. The methodology followed in this research is similar to that used by Nellore et al. [10].

PROBING CURRENT PRACTICE

The current practice can be viewed as one in which the "need" is decided more or less by the engineers. The function of the purchasers, who are not involved in articulating the need and not informed about meeting schedules, can be seen as carrying out the engineers' instructions. Since purchasing is instructed to bring in the suppliers based on the very preliminary specification developed, it can be concluded that the engineers do not try to classify the need into categories and then arrive at a certain product category (based on the importance of the project and the difficulty of managing the purchasing situation [5]). If the product category could be identified, then the supplier characteristics required to satisfy the need or product category could be determined, thereby allowing both purchasing and engineering to clearly articulate the need and the characteristics of the suppliers. It appears that an entire phase before the suppliers are actually selected is missing.

INTEGRATED ENGINEERING–PURCHASING–SUPPLIER MODEL

The integrated model (fig. 3) suggests a process by which engineering, or any other department, can identify the need during the development group meeting/s. The need will have to be articulated and discussed by the engineers, marketing, and purchasers, but there will be no discussion about the supplier or suppliers to be involved until the need is fully articulated and the category of the need has been identified. A test can be conducted to identify the category (call this test 1). Once that is done, the type of supplier required to satisfy the given category of need is explored. (That step requires a check on the supplier categories.) Finally, an assessment is made to determine the strength of the relationship and the supplier attractiveness required to satisfy the given need (test 2). This then leads to actual supplier selection. The preceding discussion demonstrates that there is a prephase before actual supplier selection. Before the supplier is selected, there needs to be a need identification phase and a match between the category of the need and the category of the suppliers. Doing so makes it possible to select suppliers whose capabilities and capacities are in tune with the requirements to deliver the component/system.

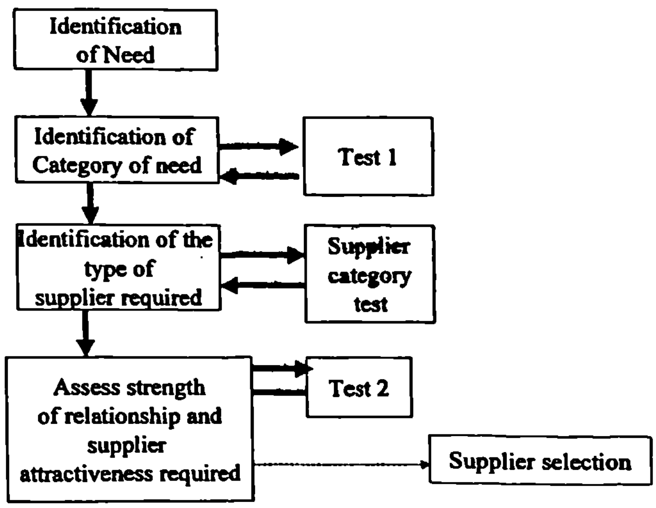

FIGURE 3: Integrated Engineering-Purchasing-Supplier Model

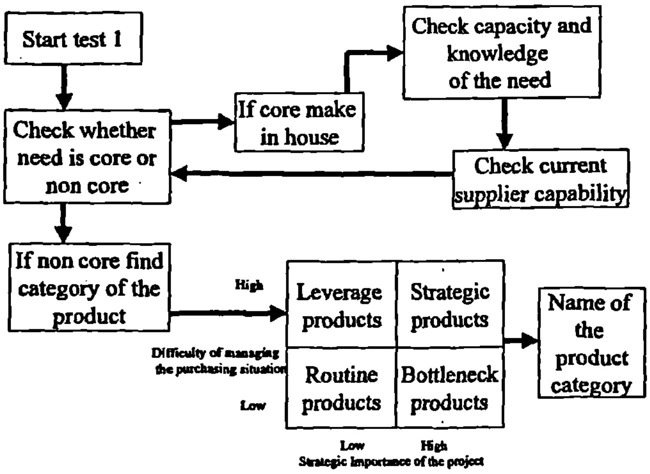

FIGURE 4: Test 1

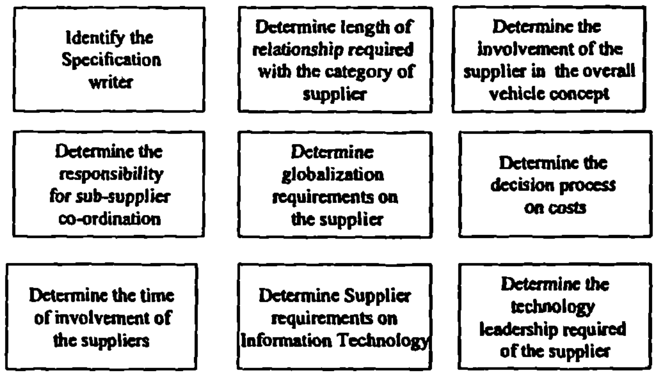

FIGURE 5: The Supplier Category test

We will now detail the individual tests that are conducted, starting with test 1 (fig. 4). The first step is to identify the need as either core or noncore. Oftentimes that decision is made by top management; however, it is essential that employees be aware of the strategies so the knowledge and capacity requirements can be built up internally should the need arise. Supply base capabilities need to be constantly checked to ensure that the OEM does not purchase products that can actually be outsourced because of supplier effectiveness (in terms of quality, price, service, technology, etc.). If the need is noncore, then the category of the need is identified, with inputs from both engineering and purchasing. Once this is done, the product category the need belongs to can be clearly identified.

Let us now turn to the type of supplier required. The case company uses four supplier categories that roughly correspond to the categories of Kamath and Liker [6]. In each of these categories, the suppliers are characterized by certain attributes (fig. 5). The attributes, which allow the OEM to ascertain that the supplier will be able to deliver to the requirements/needs placed, were identified from the interviews and should be considered when deciding on the categories of the suppliers. There is no hierarchical order of importance for these attributes. Further, neither Kamath and Liker [6] nor Araujo et al. [1] discuss the specific requirements that can be placed on the categories of suppliers, as they do not consider the product category and supplier category linkage. We are suggesting that product category–based requirements/attributes exist for the supplier categories, allowing manufacturers to ascertain that the supplier/s will be able to deliver as promised.

From the interviews, it was apparent that the importance of who writes the specification cannot be underestimated. Kamath and Liker [6] explain that partner suppliers should be able to write specifications on their own, which translates into a clear requirement for the partner supplier. This requirement can be translated for all the categories; for example, the buyer will provide a detailed specification for child suppliers. The extent of the supplier's involvement in the specification writing will also influence the supplier's ability to contribute to the overall vehicle concept and the time of involvement.

Depending on who writes the specification, the supplier can be involved early or late in the development process. It was often observed that the engineers asked purchasing to contract suppliers with whom they were working "in secret." There was little or no apparent concern for cost, a very important factor in purchasing decisions. The basis of cost decisions in each of the supplier categories can be developed to allow a clear understanding from the start of work and prevent false expectations. The engineers want to work with suppliers with whom they have had a certain length of relationship. This length of relationship can be used as a strategic option to place requirements on the suppliers, including global operations requirements. Suppliers with global operations will be able to help with issues such as balance of payments (BOP).

The "certain" suppliers that engineering would like to work with also must be audited for their technological leadership and communication infrastructure. It would be hard to classify a supplier as partner if the supplier were not a technological leader with IS/IT links to work directly with the OEM engineers. There is also a requirement on subsupplier coordination. Subsuppliers deliver components that are integral to the entire system being delivered by the first-tier supplier (supplier interfacing directly with the OEM); therefore, their performance will affect the overall product. Either the OEM or the suppliers can take responsibility for the subsuppliers to ensure performance. For instance, partner suppliers may be allowed to take full responsibility for their own subsupplier coordination, whereas the OEM may take that responsibility in the case of mature suppliers.

Finally, test 2 (assessment of the required relationship and supplier attractiveness) is conducted. This essentially confirms that supplier attractiveness and the strength of the relationship are positioned correctly to deliver a particular category of product. Further, it is necessary to identify the required strength of relationship and supplier attractiveness for each product category as suppliers can deliver any type of product required by the manufacturers (fig. 6). The relationship between supplier market attractiveness and strength of relationship between the buyer and supplier have been summarized by Nellore and Söderquist [9] as follows:

- Bottleneck components are sourced by OEMs from a limited number of suppliers. Since there are few suppliers, a medium to high supplier relationship is needed. Bottleneck components could be related to technologies the OEM does not possess but requires, which means that the suppliers need to have a medium to high attractiveness. If they were not attractive then the product/s that they supply could just as well be developed by other suppliers, leading to a leverage situation.
- With leverage components, the requirement is that suppliers have moderate to high attractiveness as they are expected to add on the "extra" to the specifications, that is, distinguish themselves from the many other suppliers. Since there are many suppliers, low to average strength relationships appear to suffice, as leverage can be maintained by the OEM.
- For noncritical parts, for which the OEM generates complete specifications, low attractiveness and low strength relationships might suffice, as the supplier is not expected to contribute to the specification and instead simply executes to the specification.
- Suppliers of strategic parts need to have a strong attractiveness and a strong relationship with the OEM as they are expected to be partners in the development of products and to take on increasing system responsibility [8].
- Our experiences confirm that suppliers who have a high or medium strength of relationship and are low on the attractiveness dimension should be removed from the manufacturers' business portfolio as they do not contribute to the brand of the OEM business that they engage in.

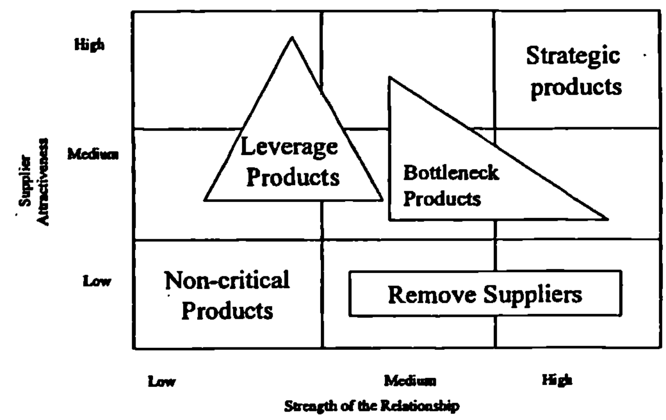

FIGURE 6: The secure check matrix (matrix dimensions adopted from Fiocca [5])

The preceding discussion is summarized in figure 6.

This model leads finally to actual supplier selection, which is beyond the scope of this article. We will use an example to show how the model works.

AN EXAMPLE

Let us assume that engineering wants to install a new instrument display system to provide enhanced safety (the system is currently used in certain aircraft in which the display is on the windscreen). Once the need is signed off, both purchasing and engineering will have to explore the category of the need. Because there is no in-house display technology and competitive pressures force a quick product introduction, it would be better to engage suppliers. The need therefore would be classified as noncore. The number of suppliers who can work with this advanced technology is small, thereby increasing the difficulty of managing the purchase situation. Further, the display technology is new to the OEM's operating segment (premium cars for which safety is a vital issue) and will become a source of competitive advantage. That fact increases the strategic importance of the project and the category of need is thus considered to be strategic. Next, the type of supplier needed would have to be explored. Based on the requirements/attributes placed on the suppliers, a partner supplier would be most suited for the job. Then, the strengths of the relationship required and attractiveness of the supplier would be assessed to ascertain that the need could be fulfilled. In this case, both dimensions need to be high. Based on this pre-work, the actual job of selecting the supplier commences. It must be noted that until this point there has been no discussion about which suppliers should be involved.

CONCLUSIONS

A model was developed for the work that has to be done before suppliers are actually selected. The analysis demonstrates that working with suppliers is a complex process, which often is reduced to a single model without connecting it to other perspectives. The integrated engineering–purchasing–supplier model will have to be extended to developing the actual supplier selection process. The following are the most important points to be learned from this study:

- Purchasing and engineering should be involved in discussing the need from the beginning, before any discussion about suppliers takes place.
- A list of requirements / attributes for each identified supplier category should be developed and used as a working document.
- Both engineering and purchasing should be involved in deciding on the strategic importance of the project, difficulty of managing the purchasing situation, strength of the relationship, and supplier attractiveness. This will have to be visible within the organization.
- Finally, within the supplier categories, provisions must be made for catering to the needs of the supplier/s. For example the costs can be decided up front when determining the decision process on costs for child and contractual suppliers.

The case company has implemented the model as a prephase stage in the development process. This requires that there be no discussion about the actual suppliers to be selected until the product category, characteristics of the suppliers, strength of the relationship required, and supplier attractiveness required to satisfy the need/s are clearly identified. A more structured approach and a closer interaction between engineering and purchasing in the actual articulation of the need have been the result.

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*This paper was written when author Rajesh Nellore was employed as a manager in the Advanced Procurement Planning Division of Scania in Sweden.

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BIOGRAPHICAL NOTE

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