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**Development of Early Supplier Involvement (ESI) Process – Study for a Case Company**

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Company**

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Master's Thesis  
Spring 2018  
Degree of Industrial Management  
Oulu University of Applied Sciences

## ABSTRACT

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Title of thesis: Development of Early Supplier Involvement (ESI) Process – Study for a Case Company

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Term and year when the thesis was submitted: Spring 2018      Number of pages: 64+15

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This thesis describes the Early Supplier Process (ESI process) to a case company's new product development projects. The objective of this research is to find out the elements that influence the need and form of early supplier involvement (ESI) and to develop a systematic process consisting of activities and considerations for managing ESI in new product development for a case company.

After the literature review, the empirical research is done as qualitative research by using online questionnaire. The answers are analyzed and compared to the existing research results, after which the benefits, opportunities, disadvantages and threats of the ESI process can be presented to management of a case company.

As a result of this thesis a systematic ESI process was created for the case company. The ESI process will be introduced in new product development projects and, where possible, ESI will be introduced the existing product projects where either qualitative, cost or time benefits are achieved

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Keywords: Early Supplier Involvement (ESI), New Product Development (NPD), Product Creation (PC) process, Lead time, Cost, Quality

# TABLE OF CONTENTS

ABSTRACT.....	3
ABBREVIATIONS AND TERMS.....	6
1 INTRODUCTION.....	8
1.1 Motivation and Object of Study.....	9
1.2 The Aim of Research and Research Questions.....	10
1.3 Research Methodology.....	11
1.4 Structure.....	12
2 EARLY SUPPLIER INVOLVEMENT (ESI).....	13
2.1 Early Supplier Involvement Advances.....	15
2.2 Early Supplier Involvement Risks and Disadvantages.....	17
2.3 Early Supplier Involvement Process.....	18
2.4 Specific Characteristics of Electronics Industry.....	22
2.4.1 Technology.....	22
2.4.2 Project Type of Action.....	23
2.4.3 Internationality.....	24
2.4.4 Production Environment and Customer Needs.....	24
3 CREATING OF EARLY SUPPLIER INVOLVEMENT (ESI) PROCESS.....	26
3.1 Research Methodology.....	26
3.2 Data Collection.....	26
3.3 Background of Answerers.....	28
3.4 Baseline of ESI.....	30
3.5 Requirement of ESI.....	36
3.6 Outcomes of ESI.....	41
3.6.1 Benefits and opportunities of ESI.....	41
3.6.2 Threats and weaknesses of ESI.....	43
3.6.3 Customer engagement to ESI.....	45
4 CONCLUSIONS.....	50
4.1 Define ESI roles and responsibilities.....	51
4.2 Define ESI process and rules.....	54
4.2.1 Specifications.....	54
4.2.2 Tolerance chains.....	55

4.2.3	Process changes .....	55
4.2.4	Supplier selection.....	56
4.3	Develop and define target/should cost for ESI parts/components .....	57
5	DISCUSSION AND FUTURE RESEARCH.....	58
	REFERENCES: .....	61
	APPENDICES:.....	65

## ABBREVIATIONS AND TERMS

EPC = EPC, standing for Engineering-Procurement-Construction refers to the turnkey activity by which a company takes up the entire range of design, material procurement and construction of a project.

ESI = Early Supplier Involvement. Concept explains the advantages of involving suppliers in cross-functional teams at the early stages of product development. It also reviews the process for working with suppliers to ensure alignment and accountability throughout the product launch and innovation processes.

JIT = Just In Time. A system in which goods are made or purchased just before they are needed, to avoid carrying high levels of stock.

NPD = New product development. Also called new product management, is a series of steps that includes the conceptualization, design, development and marketing of newly created or newly re-branded goods or services

PC process = Product Creation process. System of defined steps and tasks such as strategy, organization, concept generation, marketing plan creation, evaluation, and commercialization of a new product. It is a cycle by means of which an innovative firm routinely converts ideas into commercially viable goods or services.

PDM = Product data management (PDM) is the process of capturing and managing the electronic information related to a product so it can be reused in business processes such as design, production, distribution and marketing. It usually involves the use of a dedicated software application and centralized database

PM process = Product Management process. The process of developing and marketing a product throughout its lifecycle from launch to retirement.

R&D = Research and development (R&D) refers to the investigative activities a business conducts to improve existing products and procedures or to lead to the development of new products and procedures.

SWOT = Situation analysis in which internal strengths and weaknesses of an organization, and external opportunities and threats faced by it are closely examined to chart a strategy. SWOT stands for strengths, weaknesses, opportunities, and threats.

# 1 INTRODUCTION

Companies in many different areas of industries are facing more and more increased global competition and continuous pressures to shorten lead times and to reduce product prices. Companies are operating in markets that demand more frequent and unique innovations with faster development cycles and higher product- and process quality expectations with lower scrap costs. (McIvor R, Humphreys P, 2004) One of the most successful approaches to achieve above-mentioned targets in many companies and to gain competitive advantage is to involve key suppliers in to the concept development - and design phases as early as possible. Early Supplier Involvement (ESI) is a form of vertical collaboration between supply chain partners in which the manufacturer involves the supplier at an early stage of the product development process. (Mikkola and Skjott-Larsen, 2006; Van Weele, 2010) Multiple researches and massive amounts of different literature have identified the benefits of ESI in the new product development. (Bidault et al., 1998; Clark et al., 1991; Handfield et al., 1999) As shown in FIGURE 1, it is known that approximately 80 percent of the product's manufacturing cost is determinate by the design of the product (Clark and Fujimoto, 1991; Jaikumar, 1986; Ernst and Kamrad, 2000), and the opportunities for further savings can be achieved in the integration of product design and well managed supply chain processes during product lifecycles.

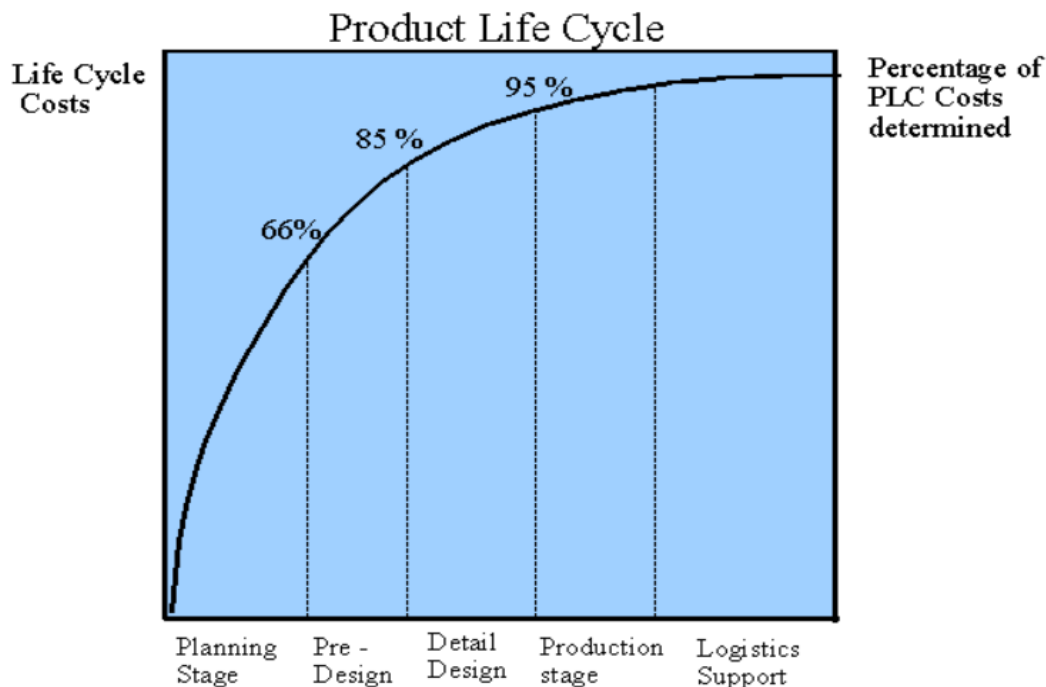


FIGURE 1. Design and Manage to Life Cycle Cost by (Benjamin S. Blanchard 1998)



Supplier involvement refers to the resources (capabilities, resources, information, knowledge, ideas) that suppliers provide, the tasks they carry out and the responsibilities they assume regarding the development of a part, process or service for the benefit of a current and/or future buyer's product development projects.

Despite of fruitful co-operation and partnership Early Supplier Involvement causes also potential disadvantages and risks. According to many studies, the major obstacle is the lack of managerial expertise needed in complex inter-organization configurations. Monczka and Trent, (1997) Therefore, companies can only benefit from this extended innovation if they develop a specific competency in managing these inter-firm relations. (Bidault et al., 1998, Wynstra et al., 2001) It is obvious that the capacity of both supplier and customer must be considered in this specific competency in order to collaborate successfully and achieve a win-win situation. One of the best and most known examples of successful ESI implementation was launched in Japanese automotive industry decades ago. (Kamath & Liker 1994) Japanese manufacturers were able to bring new automobiles to market at a faster pace, with more innovative features and with less effort in terms of development hours and number of engineers involved.

## **1.1 Motivation and Object of Study**

The decision of the content of this thesis was inspired by the vision of a case company to become "the most trusted partner imaging the unknown" by year 2020. The case company acts in electronics industry where their products e.g. devices such as x-ray imaging products, detector modules and different components, are based on high technology with small or medium volumes end of the electronic components sector.

The aim of this thesis is to study and explain the essence of the literature behind ESI topic, to find best practices of ESI from the theory and to adopt and implement them as a normal process of everyday work in the case company. In order to examine these topics in more depth, survey data was collected from employess of the case company to support case study analysis of the case company.

As a part of the process to achieve the goal Early Supplier Involvement project was chosen to be one of the key contributors to 3E, (Extend, Expand and Execute) execution projects which were ranked as a top priority future development cases in the case company. After the study, the case company will have a concrete understanding of ESI. They will also get recommendations and guidelines how ESI should be implemented to their organization in order to gain the benefits ESI can offer.

The objectives of the study are as follows:

- to identify key success factors and define key responsibilities of ESI
- to define process to guidelines and tools for ESI
- to analyze implementation alternatives of ESI

## **1.2 The Aim of Research and Research Questions**

The aim of this research is to create and implement an early supplier involvement process for a medium size company. After studied ESI in theory and references from the materials, plan is to develop ESI process to case company.

Main question of the research is:

*What are the main processes of ESI based on the theoretical background and empirical study?*

Because ESI process will be created as a joint process it needs two-way information sharing from both customer and supplier side to be as successful as possible.

Extent questions are:

*What are needed for successful ESI cooperation?*

To get ESI process as effective and beneficial as possible for both parties' cooperation and information distribution related to e.g. time, materials, money and resources need to be open and accurate. ESI as a topic is wide and therefore it is important to find out key areas that are important to be included to the ESI process of the case company:

*Which items are essential to be included to ESI process?*

Creating and implementing ESI process as a normal new product development process both customer/buyer and supplier/seller will gain many advantages. These can be defined by asking:

*What are the benefits for the companies/partners if ESI process will be created and implemented?*

### 1.3 Research Methodology

As mentioned above the result of this study will be Early Supplier Involvement process for the case company. Research method used in this research will be qualitative research with descriptive and constructive approach. Based on Hirsjärvi & Huttunen (1995, 174,201) qualitative research provides valuable data for use in the design of a product/process, including data about user needs, behavior patterns, different point of views and use cases. Qualitative research is useful when needed information should be detailed, descriptive, individual and subjective. Qualitative methods are often part of survey methodology, including telephone surveys and consumer satisfaction surveys as FIGURE 2 shows. Qualitative method allows the researcher to be more creative in terms of both data collection and data analysis composed by Mukhopadhyay & Gupta (2014)

Qualitative research material (data) will be analyzed with interpretive techniques by analyzing the content of interviews and case study as described by Yanow and Schwartz-Shea (2006). The main purpose of this study is to clarify how well the employees of the company know the benefits of the ESI process and what are the measures in the company where the benefits are achieved.

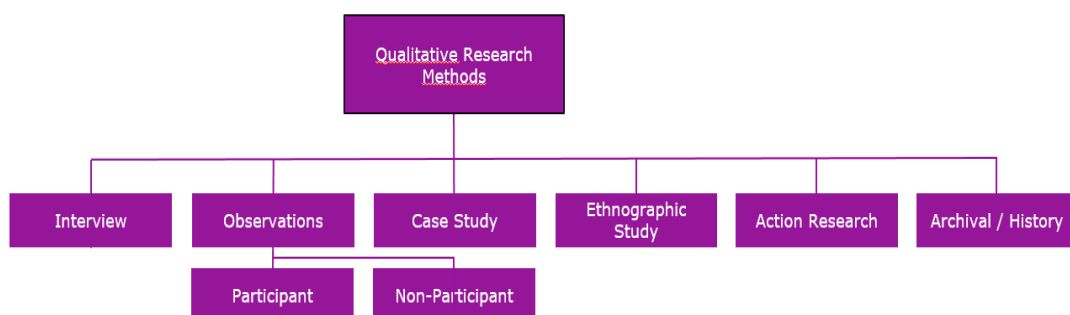


FIGURE 2. Research methods used by qualitative researches by (Mukhopadhyay & Gupta 2014)

## 1.4 Structure

This study is divided into six chapters. In the first chapter the topic and the aim of the study are introduced. Chapter two contains a literature review to build a theoretical background for the study. Firstly ESI is introduced in general and advantages and possible barriers of ESI are studied and described. After introducing the basics of ESI these are combined and analyzed together with by integrating principles of ESI in to a new product development. This is the main part of the literature review. The ESI process for the case company will be created by using the existing theory and with the details received and analyzed based on the questionnaire made during the study.

In chapter three, the research methodology is described. The selection of the research strategy is motivated and collecting and analyzing of the data is described. In chapter four the results received and analyzed based on the questionnaire, answers are presented. The chapter compares the results to the theory and points out if the findings match to theory. In the fifth chapter, the conclusions are summarized and proposals for possible future research are made.

## 2 EARLY SUPPLIER INVOLVEMENT (ESI)

Early supplier involvement (ESI) fulfils upfront supplier resources and expertise to accelerate the research and development (R&D) timeline, and allow for risk sharing. Early Supplier Involvement takes place when for example new products or existing product change and continuous improvement are all product development initiatives. Pressures, which are related to tough global competition and fast technology changes, have both shortened product life cycles and that is why new products and processes are needed rapidly. Additionally, existing product changes resulting from regulations and safety considerations also initiates product modifications. Worldwide competition pushes change relating to cost reduction and thus require for continuous improvement processes.

*Early supplier involvement can be seen as a means to integrate suppliers' capabilities in the customer's supply chain and operations, thereby making it possible for the customer to take advantage of the suppliers' technological expertise in design and manufacturing (Dowlatshahi 1998). Early supplier involvement is a relative concept since there are different levels to it, where the supplier's involvement ranges from low to high. At its lowest level of ESI can be just about providing information on the equipment and capabilities so that the customer's design team can integrate the information. At the highest level of ESI the supplier can take full responsibility for a part or sub-assembly, from concept to manufacture. (Bidault et al. 1998.)*

As presented in FIGURE 3 suppliers involvement in ESI can vary from “0 to full” responsibility depending on customer relationship and trust towards supplier. The lowest level of supplier integration in new product development is naturally no involvement at all.

None	“White Box”	“Grey Box”	“Black Box”
No supplier involvement. Supplier “makes to print.”	Informal supplier integration. Buyer “consults” with supplier on buyer’s design.	Formalized supplier integration. Joint development activity between buyer and supplier.	Design is primarily supplier driven, based on buyer’s performance specifications.



FIGURE 3. Spectrum of supplier integration by (Handfield et al. 1999)

In the spectrum of supplier integration the “None” level includes the situations where the supplier has no involvement in the customer’s product development, but merely supplies the needed parts or products according to the specifications provided by the customer. When the situation moves to the level of “White Box” involvement, the supplier is consulted informally in the customer’s product development process. There are discussions about specifications and requirements between the supplier and the customer, but the customer still makes all the decisions concerning the design and specifications. (Petersen et al. 2005.)

When moving towards the “Grey Box” level, the joint development activity between the supplier and the customer becomes more formalized. There can also be information and technology sharing, and joint decision making concerning the design and specifications. When the supplier involvement grows near its highest levels, the level of integration becomes the “Black Box” level. This means that the design becomes primarily supplier-driven, and is based on customer’s performance specifications. The supplier is informed of customer requirements, and then is given almost complete responsibility of the purchased item, whereas the customer’s role is mostly to review and accept the purchased item’s specifications. (Petersen et al. 2005.)

## 2.1 Early Supplier Involvement Advances

As mentioned in many books and different articles e.g. (Monczka, et al. 2000); (Peter M, 1996.)

early supplier involvement is driving by following requirements:

- speed of technological and material development
- possibility to gain bigger market shares
- shorter product life cycles
- improve product/process quality
- improve product/process design and manufacturability
- increase efficiency and flexibility
- Increase cooperation and transparency between supplier and buyer. (customer-supplier)

Early supplier involvement requires open discussions, data- and idea sharing and deep cooperation between customer and supplier very beginning of new project. Generally, ESI starts already when product is still in concept (innovation) phase. As soon as supplier will get information about new product or design from customer (buyer), it can start put right engineering recourses and best ideas to new product design work.

According to Handfield et al. (1999) overall ESI should be part of whole new product development process, but at least three main tasks which can be named: as planning, designing and manufacturing.

Planning phase:

1. The understanding of product scope and definition, how is the product used and what conditions it will be subjected to.
2. A defined supplier – customer (buyer) interface where customers determine the functional specifications and suppliers (or cooperation with customer own engineers), provide detail engineering.
3. Platform design specifications to determine the restrictions within the product systems interface

Design phase:

1. Cooperation in design
2. Cooperation in important tasks like
  - a. design/process FMEA
  - b. 3D files, sharing CAD files
  - c. material studies and right material decisions
  - d. Bill of Material creation

- e. Prototype series manufacturing. (how many? when? why?)
- f. cost saving studies (proper and well design product saves money => 80% of the manufacturing cost of a product is determined by its design)

Manufacturing phase:

1. Eliminate waste
2. Support thinking of Lean production
3. Design for manufacturing (DFM)
4. Decrease inventory levels
5. Cooperation in Kaizen events

In best cases, ESI leads very beneficial strategic partnerships between customer and supplier.

The degree of supplier – buyer interdependence relates to the extent of supplier involvement in product development. Long-term positive effects from ESI can be summarized as many studies presents. (Bonaccorsi and Lipparini, 1994); (Helper and Levine, 1992); (Ring and van de Ven, 1994), (Clark 1989); (Kalwani and Narayandas, 1995)

- lead to capabilities benchmarking
- develop trust and transparency
- create inter-firm knowledge
- have common beliefs relating to "Best Practice Methodology"
- risk and investment more safe to do (including demand variability)
- Agreements support their interdependence (between customer-supplier)
- A single source relationship preference (A high asset and technology commitment specified by the customer)
- Many resources needed from both parties. Expanded innovation expected.

In terms of efficiency, supplier involvement can lead to the reduction of development costs and the reduction of development lead-time. This is mainly achieved by preventing, reducing or introducing design changes earlier by means of early and intensive communication with the supplier ('first time right' development). It is also realized by separating development tasks, and developing various components or modules in parallel, which helps to solve capacity bottlenecks in the manufacturer's engineering department. Finally, when for each phase in a development project, design (development or engineering) responsibility is given to the most competent company of the two — the supplier or the manufacturer — efficiency is also promoted. (Wynstra, van Weele and Weggemann .2001)



Trent (2007, p. 227) presented a summary of the findings of several studies with regard to benefits of supplier involvement versus cases where supplier was not involved. The benefits are presented in TABLE 1. The table suggests that involving the suppliers led to significant benefits time, costs, and quality and product performance.

*TABLE 1 Benefits of supplier involvement in new product development compared to projects with no supplier involvement*

	Early	Middle	Late
Reduction in material costs	20%	15%	10%
Reduction in development cycle time	20%	20%	10%
Improvement in material quality	20%	15%	15%
Reduction in development costs	20%	10%	10%
Reduction in manufacturing costs	10%	12%	10%
Improvement in product functionality, features and technology	20%	10%	10%

## **2.2 Early Supplier Involvement Risks and Disadvantages**

As written earlier, in best cases ESI implies many potential benefits for both parties the customer and the supplier. However, it is also important to recognize that there are also potential risks and disadvantages involved in ESI utilization. Mainly the risks are discussed only from the customer's viewpoint since literature and studies often covers this perspective. It has been noticed at least three main risks concerning supplier involvement in product development which relate to dependency, reduced flexibility, and information loss. (Wynstra 1998: 50)

Increased dependency of the customer on the supplier is the result of increased collaboration, information exchange, and commitment to and selection of a certain supplier. (Wynstra 1998: 50.)

Decreased flexibility is related to the dependency between parties. It stems from the fact that by committing to a certain supplier, the customer also commits to its capabilities and their limitations, and to the technologies, the supplier uses. This risk is especially relevant in projects where the degree of innovation is high. (Wynstra 1998: 50-51.)

The relevance of this risk is also supported by the notions that high levels of technological uncertainty increase the complexity of ESI utilization. (Johnsen 2009)

The third main risk is the loss of information because in supplier involvement sensitive information is shared to parties outside the company. The risk of leaking information about, for example, technical details of a new product or technological knowledge of the customer increases when this kind of information is shared with the supplier. This risk is especially relevant when the supplier is involved in co-operation with the competitors of the customer. (Wynstra 1998)

### **2.3 Early Supplier Involvement Process**

First Early Supplier Involvement processes have been developed in the Japan's automotive industry in 1980. After those "benchmark" process descriptions many industries (i.e. telecommunications, consumer electronics) have created their own processes which have been modified and adjusted to fit everyone own needs and requirements of ESI.

Implementing of ESI process to company's own processes has changed ESI process requirements towards industry but always in ESI we should take into account following functions:

- Design
- Procurement
- Suppliers
- Manufacturing

A "startup" that is needed to design a new product that may require a customer or a strategic management decision for the need for a new product that either extends the product range or increases market share in a particular product segment. Next comes the concept stage where engineers' research and brainstorming will bring about a new product design. First prototypes are then prepared and manufacturing processes are analyzed and piloted until the final specifications have been finalized and signed.

During each design process, the engineer needs to outsource the supplier from any part and machine to the actual machining and manufacturing - depending on the features of the product or application. Often, designers / engineers do not have the time to look for decent design for manu-

facturing (DFM) reports from suppliers but are busy dictating schedules. This can lead to subcontractors developing technically and qualitatively "cheaper" alternatives for the manufacture of parts. Although parts prices may be cheaper but their quality and usability may be affected => so new design and manufacturing rounds may be required to allow the end products to be assembled, for example, according to customer requirements.

Therefore, the involvement of an early supplier (ESI) is recommended in the early stages of product design - most designers say "earlier, the better". The best cases ESI introduces an engineer with a direct description of the supplier's capabilities. ([www.pmiquality.com](http://www.pmiquality.com)) When suppliers participate at an early stage of project planning, it provides cost-effective impacts, facilitates project preparation and ultimately shortens the concept and production times.

As FIGURE 4 shows, the ESI process is not just one organization's responsibility; it is the result of cross-functional cooperation between different organizations.

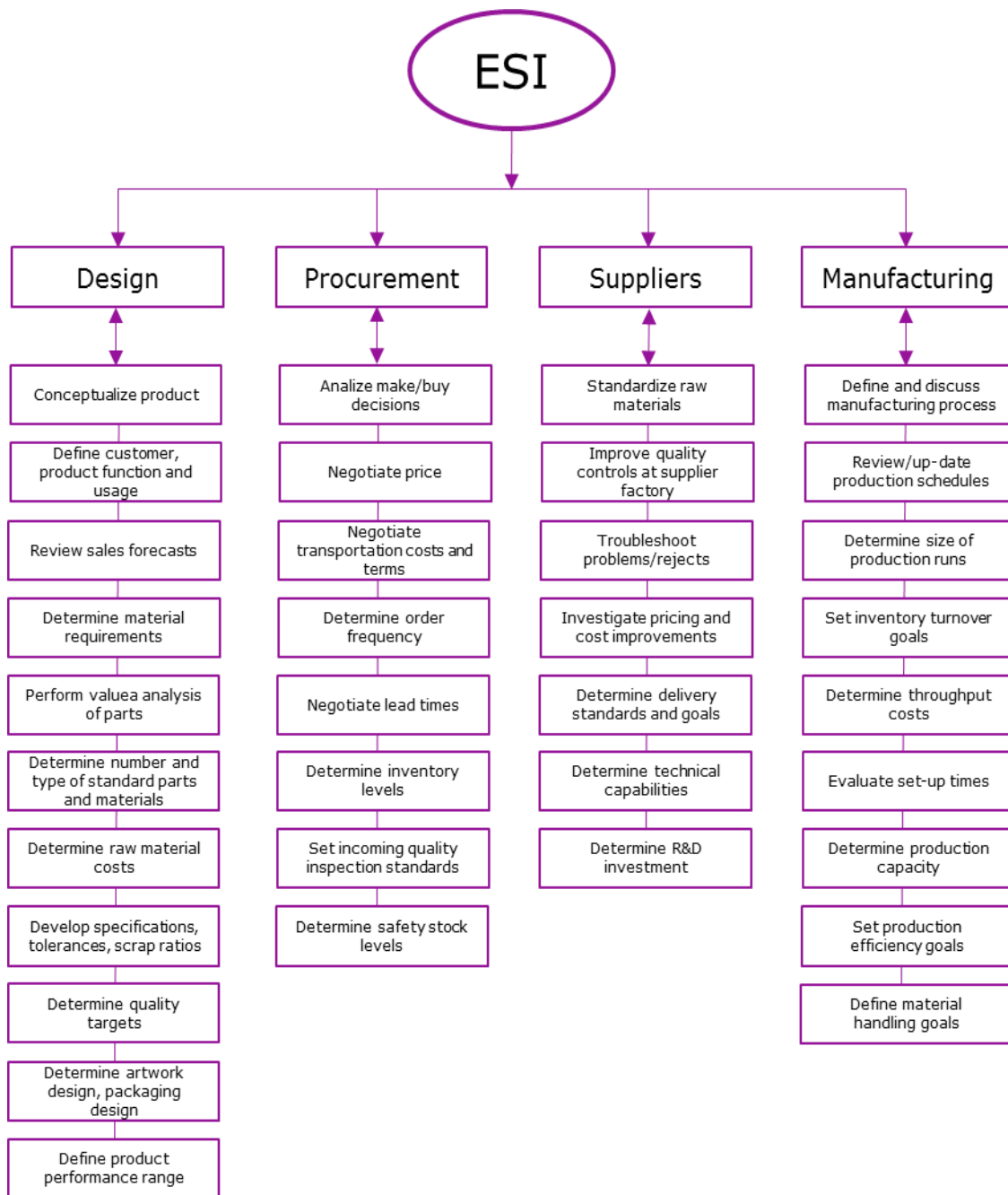


FIGURE 4. ESI conceptual framework by (Ellram and Cooper, 1993)

The ESI conceptual framework presents many opportunities for improvement in the company's product development process that were not considered by the company. Dowlatshahi (1999) When implementing effective and functional ESI process at least following processes, roles and responsibilities need to be in place as described in TABLE 2.

TABLE 2. The main prerequisites and recommendations for implementing ESI include the following. Adapted from Dowlatshahi (1999)

Propositions	Corollaries
An effective ESI implementation requires a formal plan that is specific, concrete, and comprehensive.	An effective ESI implementation requires a permanent, full-time team leader who has overall responsibility for the program.
An ESI program is only possible when relationships with suppliers are of a long-term and partnership nature.	Preferred and major suppliers in ESI should be certified and committed to the buyer's ESI program.
An effective ESI program requires a multi-disciplinary team with necessary powers, authority, and knowledge to implement the program fully.	The ESI multi-disciplinary team should include representatives from design, procurement, suppliers, and manufacturing
An effective ESI program cannot succeed without the full support and involvement of the customer's top management.	Without the full support and involvement of the customer's top management, crucial design and materials decisions in ESI cannot be properly made.
An effective ESI program requires simultaneous integration of various ESI activities and tasks.	The proper integration and simultaneous consideration of ESI activities and tasks require an organizational culture that is conducive to effective interdepartmental communication and co-operation

- 1) There has to be a formal plan and structure in place for ESI implementation. Programs that lack specificity and a formal approach are usually inadequate and ineffective. It is also advisable to have a responsible party or full time ESI team leader in charge of the overall ESI program.
- 2) Only suppliers with long-term relationships and partnerships with the sourcing should be expected to participate in the ESI programs. This necessitates that the suppliers be certified and prepared to commit themselves on a long-range basis.
- 3) The ESI process requires an effective cross-functional team. This team is essential in building a consensus and facilitating dialogue and communication among various stakeholders and departments. The team members should be drawn from design, procurement, suppliers, and manufacturing groups. This appears to be a prerequisite for implementing an effective ESI program.
- 4) Effective ESI programs require the support and involvement of top management. Without this support and involvement, major decisions regarding product design and strategic material development will not be happened.

- 5) Most of the tasks presented in the building blocks of an ESI conceptual framework should be considered as interdependent with one another. Whenever appropriate, the tasks must be considered and performed simultaneously. For this to occur, the culture in the company must be conducive to effective interdepartmental communication and cooperation. Only then can an effective ESI program be implemented.

## **2.4 Specific Characteristics of Electronics Industry**

Each industry sector has their own features, which have implications for product requirements, product designs, and material selections in products, production processes that will be used and developed during new product development process. In the electronics industry, the aforementioned issues play a very important part due to the high quality standards and long life cycles of the products. For this reason, the ESI process describes well the electronics industry's characteristics.

### **2.4.1 Technology**

The specific nature and content of the products being manufactured, the general technological advancement and the strong networking of the companies that manufacture the technology pose challenges to high technology companies. Almost all products in this industry are made up of software and various mechanical and electronic components. Combining these various components into one entity can be difficult due to the different design and manufacturing processes and the life cycle. Product and component life cycles are shortened and products using the latest technology have to be placed on the market as quickly as possible. Especially in the procurement of electronic components this may mean an increase in uncertainty. The availability of components may be poor and the delivery time of the components is long in relation to the lead-time of the actual product. (Sääksvuori & Immonen, 2002, 120-121.)

According to Gadden and Håkansson (1993, 13-14), the company's technology defines the range of products to be bought, which in turn directs the decision on which suppliers are interesting. For example, if a purchasing company focuses on developing tailor-made solutions, flexibility and adaptability are required from both the purchaser and the suppliers.

Electronics companies can be described as both mass production and unit-manufacturing companies, as the products in the industry have large lifecycle volumes, but on the other hand, large

volume products are tailor-made for customer needs. In connection with mass production, production must be efficient and accurate, and thus material and component streams must be stable and secure. In mass production, maintaining competitiveness is important, which means that the company also must develop its supplier relationships. Companies with mass production have already professionalized purchasing at an early stage. This is due, among other things, significant financial impact of the components. Often, buyers are aggressive and require their suppliers to adapt to their demands. (Gadde & Håkansson, 1993, 13-14, 22-24.)

Unit manufacturing is in turn characterized by the fact that the products are manufactured according to the customer's special requirements. Product development is the main function of the units manufacturing companies. The products are designed together with the customer and the customer also participates in identifying potential problems. As only a few components are manufactured in house and the focus is on component assembly, suppliers have an important role to play. Suppliers are required to have resources to develop, design and manufacture products that are part of the finished product. Often, buyers of the buyer are interested in the components of the product being purchased, even if they buy the assembly and not a specific component. The challenge of purchasing may be that individual customers may want the components of certain suppliers to their assembly because they have good experience from these vendors. Here too the importance of technology is emphasized. Companies operating in the field often have a limited network of suppliers and companies work closely with only a few suppliers. (Gadde & Håkansson, 1993, 19-20; Schary & Skjøtt-Larsen, 2001, 326.)

#### **2.4.2 Project Type of Action**

In addition to technology, electronics companies are characterized by their activity based on projects. ANSI defines (project management institute, 2004, 5-7) projects as temporary activities designed to engage in a personalized product, service or result. Projects are characterized by both temporaryity, individuality and progressive design. Project creation is influenced by market demand, customer needs or technology-related benefits.

Gadde and Håkansson (1993, 21) have also paid attention to the significance of the projects. Individual projects often require a project team, whereby the project promoter takes care of project-time purchases, while production purchases are equivalent to purchases after product switching to

production. The product transfer from the project team's responsibility to purchasing production plays an important role. It can also cause problems between organizations. According to ANSI (Project Management Institute, 2004, 14), understanding the project environment requires a lot of different contexts. These include cultural and social factors, the international and political atmosphere and the physical environment.

### **2.4.3 Internationality**

The electronics sector is well illustrated by the word internationality. It is important to take account of the international nature of production in the supply chain planning. The factories have to be located close to markets, technology sources or cheap labour. Often, companies have several production facilities around the world. The global production system is a network where logistics plays a major role in combining production processes. Shipping determines delivery times for orders and the ability to respond to changes. Global networks are accompanied by the pressure to create local supplier relationships so that both their staff remain satisfied and the technology is transferred to the production country. (Scharj & Skjøtt-Larsen, 2001, 150-151.)

Internationalism also brings about infrastructure and cultural differences. Infrastructure refers mainly to transport, telecommunications and government assistance. Cultural differences arise in the attitudes and education of employees and in the business climate of the country concerned. (Scharj & Skjøtt-Larsen, 2001, 151-152.)

### **2.4.4 Production Environment and Customer Needs**

Because of the global market, flexibility is required on products and volumes while the plant is growing. As volumes increase, the capacity of the factories has to be increased. On the other hand, customer needs are unstable, but they have to be responded quickly. In addition, customers want products to match their individual requirements. Product life cycles are becoming shorter and companies' product range expands. These requirements set challenges to inventory management. Due to the short product life cycle, fixed costs should be covered by higher gross margins; on the other hand, the margin percentages require lower manufacturing costs. (Scharj&Skjøtt-Larsen, 2001,152-153.)



One of the peculiarities of the electronics industry is the JIT buy-in (Just in Time). According to Bloomberg et al (2002, 31-32), several features related to quality, transportation, suppliers and quantities define the JIT purchase. According to Scharyn & Skjøtt-Larsen (2001, 155) JIT is the philosophy of continuous improvement, whereby employees are committed. One of the most important features of JIT buying is to ensure the availability of materials while at the same time seeking zero stock. Ensuring availability of materials at low transport costs requires close supplier relationships. Time and long distances in the international market also pose additional challenges for implementing the JIT acquisition. (Ballou, 2004, 428.)

The pursuit of JIT purchasing is beneficial to both the buyer and the supplier. The benefits to the buyer may mean i.e. productivity growth as material costs become lower and delays in deliveries decrease. Administrative efficiency improves when there are fewer contracts and suppliers, and thus communication and accounting are more accurate. Lower storage and transportation costs and lower amount of material waste reduce material costs. Better quality ensures faster response time with defective material, fewer checks and better end product quality. Improving the design of the material speeds up the possible transformation processes and innovating design. The supplier benefits from JIT activities, for example, as the turnover of the personnel is decreased by with better training, scheduling predictability, capacity requirements, and production schedules. Material costs are reduced because suppliers are engaged in JIT purchases with their own subcontractors too. Quality improves when the production batches are reduced and more attention is paid to quality assurance. (Bloomberg, Lemay, Hanna, 2002, 32; Schary & Skjøtt-Larsen, 2001, 166-167.)

### **3 CREATING OF EARLY SUPPLIER INVOLVEMENT (ESI) PROCESS**

The research method is described and its results are collected and analyzed in this chapter. In addition, the basis of the ESI process and its requirements based on the responses sent to the questionnaire are studied. At the end of the chapter, the benefits and opportunities, the disadvantages and the threats of the ESI process are presented in response to the replies to the questionnaire.

#### **3.1 Research Methodology**

The key features in ESI process will be defined by theory. Theories can be used as a starting point to find out most common characteristics of ESI processes of different industries. After the theory was explored, questions were created and an online survey was conducted to which respondents responded from their own web browser. All the responses were saved to the cloud service, from which they were easily analyzed and reported for different purposes. During the questionnaire researcher gathered relevant information and ideas about existing ESI from both case company and its customers when questions were related to customer segment. The selection for respondents was subjective and based on researcher's decision. The questionnaire was sent to people in different key positions in different key organizations in a case company. Because all of the respondents did not located in Finland, the interviews were conducted in English. The actual questionnaire structure used in the inquiry is therefore also in English. The questions asked from the interviewees can be found from APPENDIX 1. After that the empirical evidence was compared to the theory and previous studies about ESI and finally ESI process for the case company was created (process flowchart) and executed as a work process of new product development.

#### **3.2 Data Collection**

Structured questionnaire survey was chosen as a study mode, because of the advantage of objectivity, directionality large number of people, as well as responding speed. Research data was collected by an online questionnaire. This way interviewer effect on the results was avoided, receipt of responses was fast, the individual respondents remained anonymous, as well as survey method

allowed the submission of sensitive issues. In Internet surveys, the answers are stored in a database, from which data can be processed and analyzed in different statistical programs at the end of data collection. (Heikkilä 1998, 20, 69.) Those who participated in the survey were sent a cover letter by e-mail with a direct link to the survey. The survey was conducted in February 2017.

Differences between countries, organizations and working experiences of the company were specified in order to find out divergences and mindsets of the different answerer. Questions divided to closed questions and open questions. Closed questions have multiple answer choices providing possibilities to find out differences between organizations and working experience of the company's employees. Open questions will give possibility to tell little bit more about own ideas and wishes. Main idea is still to find out best practices and the most suitable process for ESI.

The questionnaire was sent to 108 people: 71 responses were received and the response rate was 65.7%. Response rates vary by issue-specifically, as all participated in the survey had not answered all the points. This contributed to a large number of propositions in survey. The questionnaire contained 47 questions, of which 41 were closed multiple-choice questions. The answer options of questions from question 4 to question 16 were: 0 = not at all, 1=little, 2=some, 3=much, 4=very much, 5=don't know. The questions from 19 to question 27 were 0 = very bad, 1=bad, 2=ok, 3=good, 4=excellent, 5=don't know. The rest of the six questions were open-ended questions to which respondents were asked to give their own ideas, views and experiences freely. Claims in respect of the respondents were given ready-made answer alternatives. The aim was to simplify the processing of the responses and to combat linguistic errors, and to facilitate the adoption of criticism. The questionnaire was divided into different aspects of the theory of issues have arisen, as well as existing processes and process development based on the needs. Questions were modified and divided to suit the survey based on the literature. Questions 1-3 described the respondents' background information. Claims 4-15 identify the organizations internal information on their own and suppliers' practices. Claims 16 to 31 identify the various department's responsibilities, know-how, capability, adequacy of resources and motivation factors. Claims 32-38 will answer the anticipated benefits of the ESI process. Questions 39-44 clarify customers' attitudes towards ESI process. Questions 45-47 give a comprehensive reply to ESI positive and negative aspects of the process.

### 3.3 Background of Answerers

Respondents were asked basic information about the following things: work organization inside the company, work experience in a company (in years) and working premises in the company (country). As we can see from FIGURE 5 almost 50% of answerers are working for engineering and 15.5 % for business units. 12.7 % works for production/operations and 9.9% works for quality department. The rest of the answers were distributed evenly among other organizations.

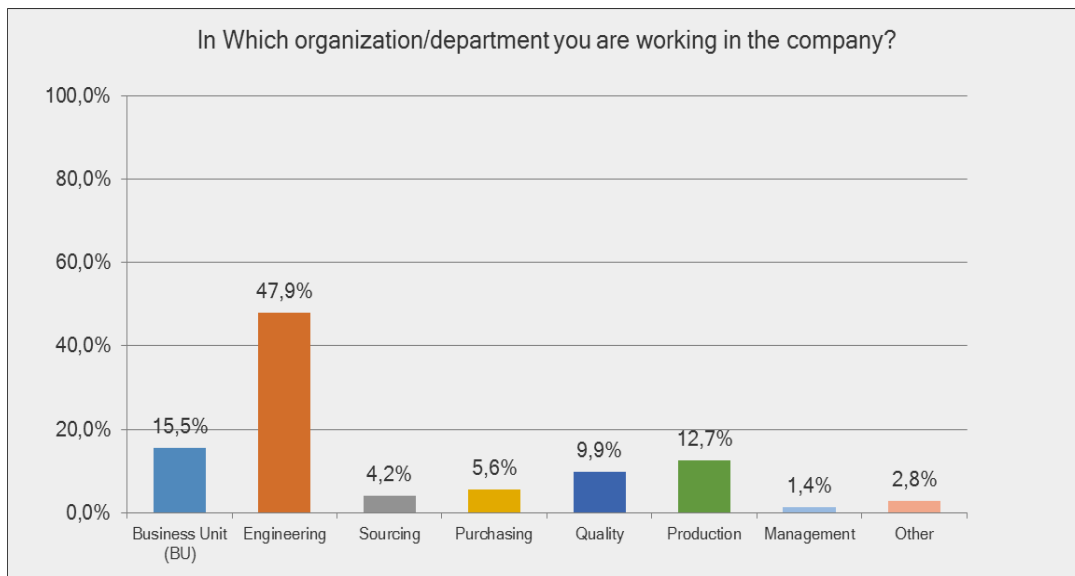
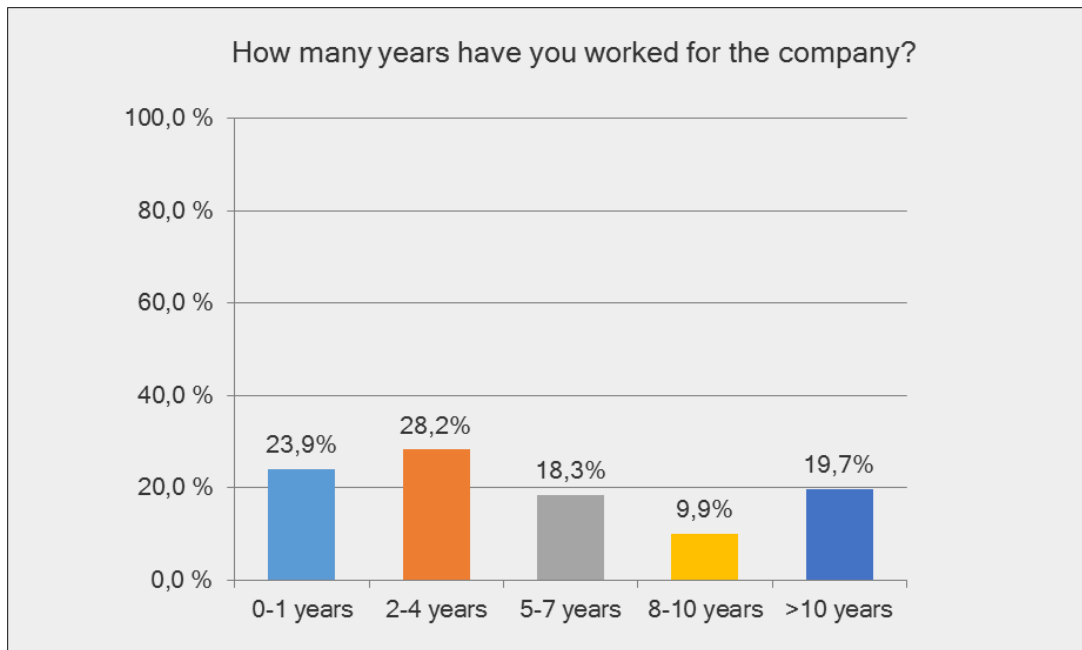


FIGURE 5. Work organizations of answerers who replies to survey

FIGURE 6 shows how working experience in the company has divided with different groups. As results shows; working experience distributes from 0 to over 10 year experience inside the company. Results from the survey will represent a good and realistic view about answerer's opinions from different areas of the questionnaire..



*FIGURE 6. Working experience distribution in years in the company*

FIGURE 7 illustrates in which country and in which premises the employees are working; 43.7% of the answerers are working in Finland. Totally, 52.2% of answerers are working in China and 4.2 % are working in the USA.

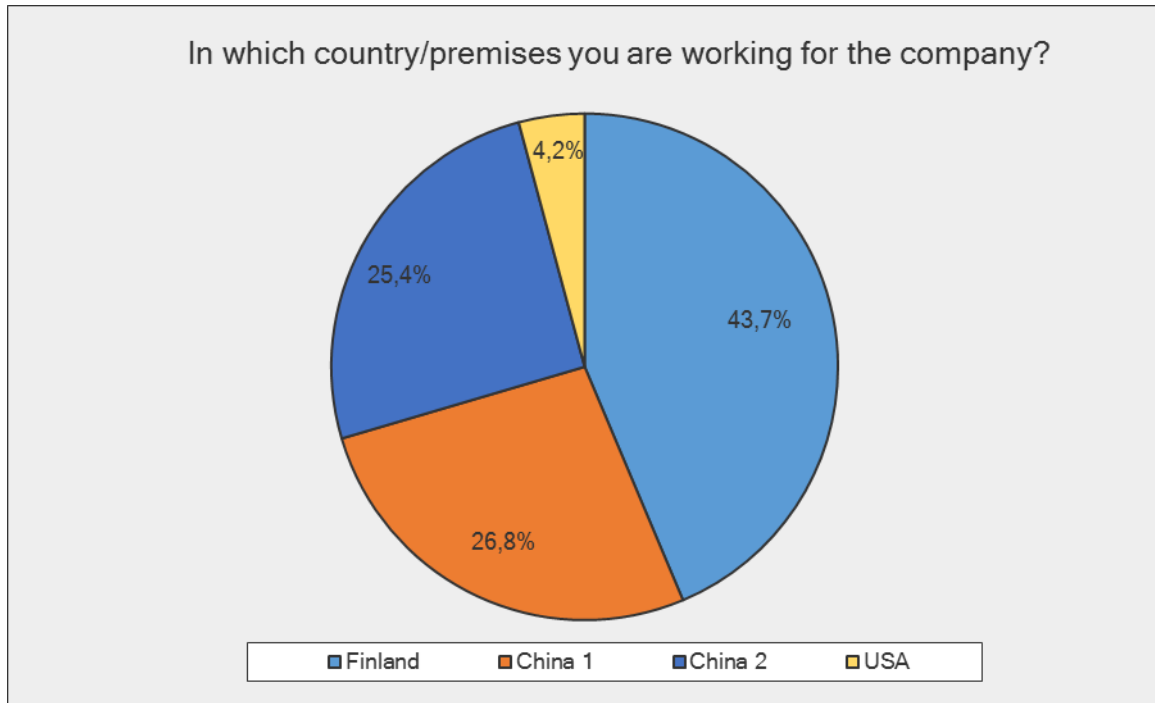


FIGURE 7. Share of workers from different company premises

### 3.4 Baseline of ESI

At the end of 2016, three important future development projects were selected. One of the most important 3E (Extend, Expand and Execute) projects was selected as an ESI project, which was selected because, in the past, there was no systematically derived supplier integration process in place in the case company.

Previously key suppliers were identified and some co-operation were done but not very systematic or controlled way. Basic rules and processes for new supplier selection and new supplier integration were documented and relevant personnel had only access to it. It included information about which products, components or materials are going to be developed in design cooperation with a supplier and what the strategies for those are.

Guidelines for the methods of "ESI" were quite familiar and it might be discussed but not written nor described to employees of case company. Knowledge of supplier co-operation was created at

some level but awareness of how the information was distributed to the personnel was unclear or missing. There was no common infrastructure or IT system for supplier integration. Methods were mostly at practical level in personal ways of acting mainly in sourcing team.

Part of the “pre ESI project” key suppliers were categorized and commodities were established. The case company sourcing department structured again to focusing own commodity areas more effectively. Anyway, the company had started to use cross-functional team meetings during design processes in order to give other departments the opportunity to affect to the product design and manufacturing processes before any crucial milestone or final approval of the design. As FIGURE 8 shows 65% of the answerers felt that co-operation is in good level in the company. Co-operation was mentioned to be “normal “way of working and it was clearly seen as a strength of company. Co-operation between different organizations in the design phase is one of the most important tasks in ESI process as Handfield et al. (1999) also mentioned in their report.

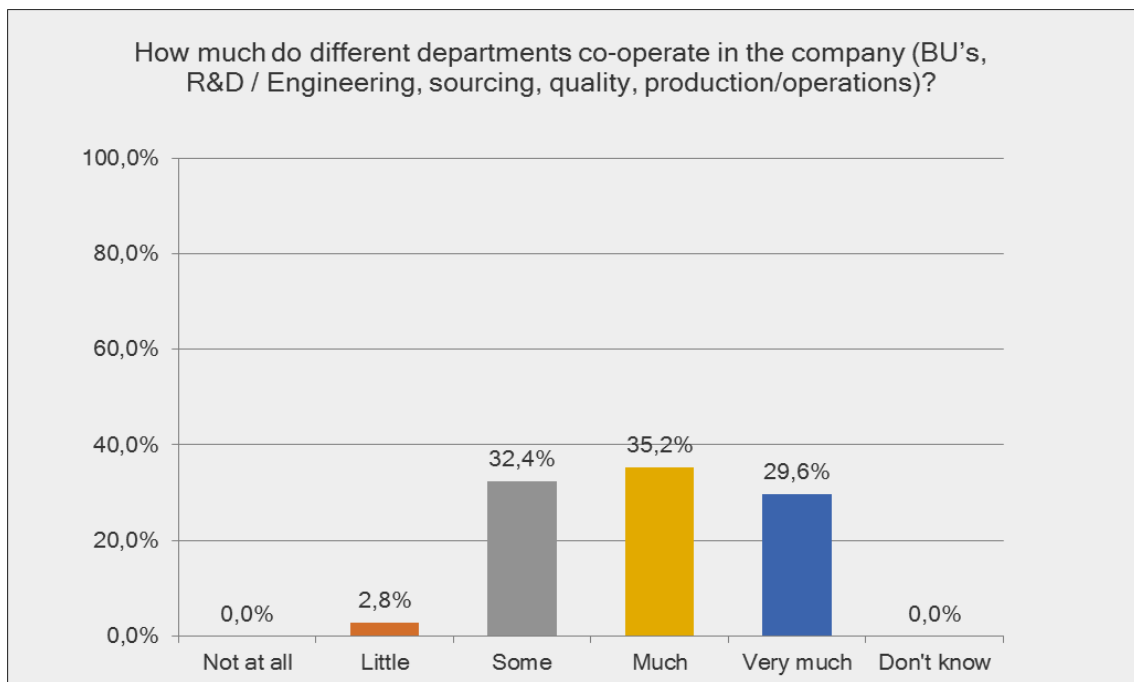


FIGURE 8. Cross functional co-operation in the company

As seen in FIGURE 9 41% of respondents believe that cross-functional design is already being done in the case company.

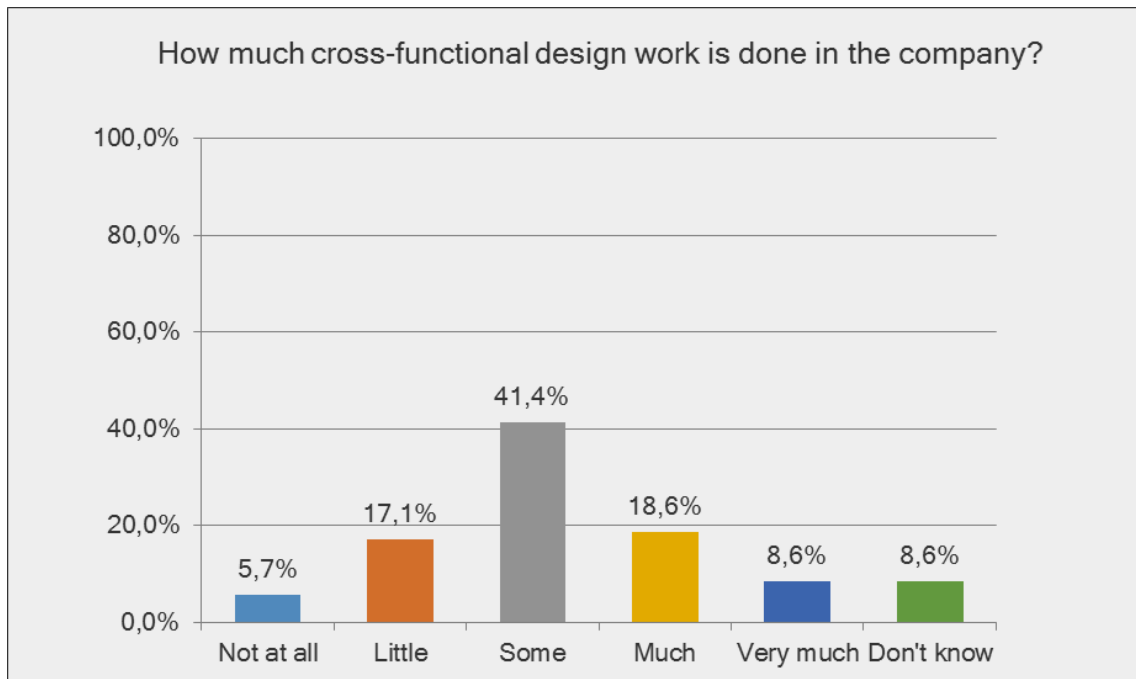


FIGURE 9. Cross-functional design work inside the company



Based on the opinions of the answerers the company has done some (40.8%) or little (31.0%) co-operation with key suppliers earlier. "Preliminary ESI" actions have been in place in case company's PDM process earlier without defined ESI process as FIGURE 10 shows.

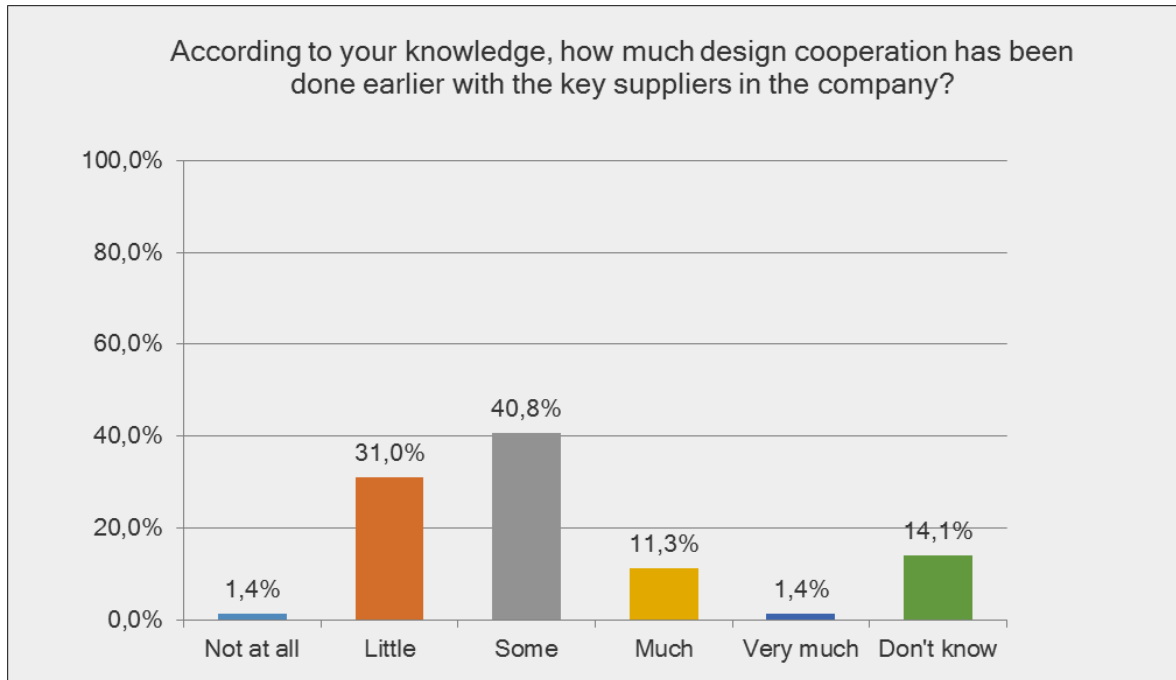


FIGURE 10. Co-operation with key suppliers

More than one third of the respondents, FIGURE 11, believe that the main criteria's of supplier selections are based on long-term requirements and operative issues.

Long-term requirements are good cooperation, fast design feedback, reliable partner with good quality and reasonable cost structure.

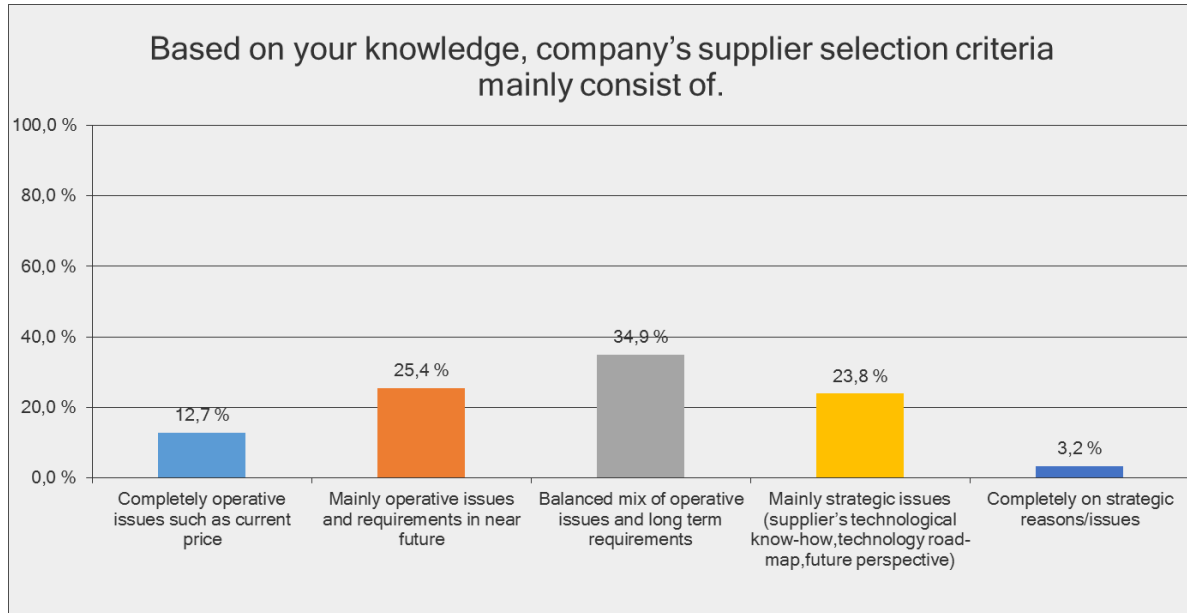


FIGURE 11. Case company criteria's of supplier selection

In FIGURE 12, more than 90% of the respondents clearly stated that the ESI process should start before the "right design" start. Parker et al. (2008) suggested that several project specific factors have a relation to the extent and timing of involvement. The emerged need for new technology in a project was found to be connected to involving the suppliers earlier. The case company's products include; a lot of new technology that is highly specific and unique and whose specific features are characteristic of this industry.

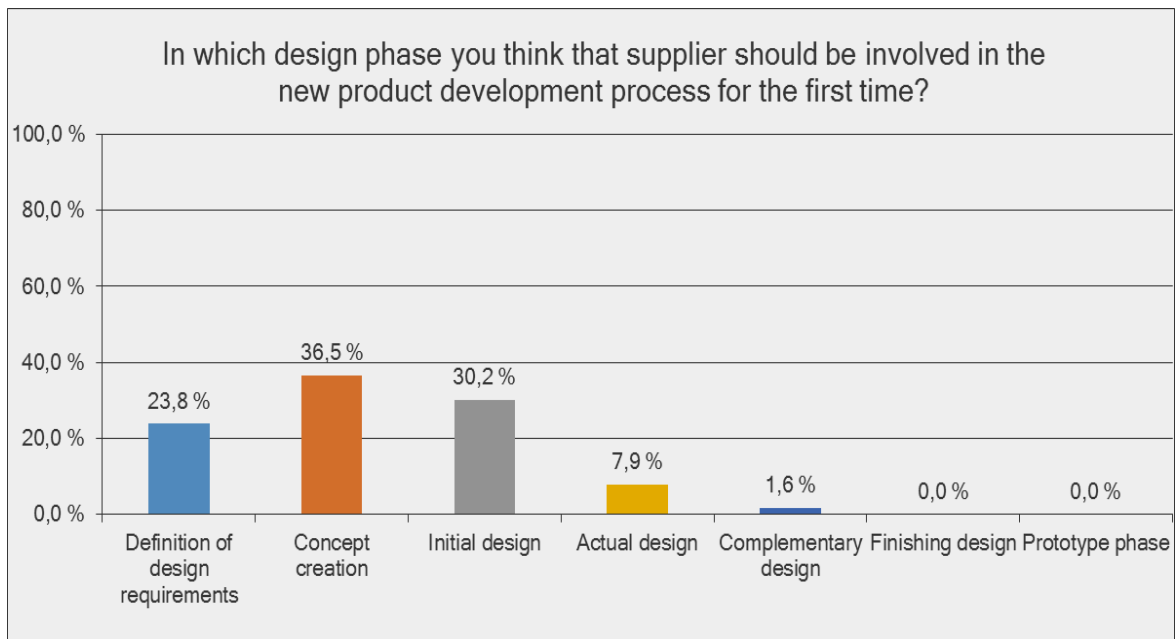


FIGURE 12. Timing of starting ESI cooperation

### 3.5 Requirement of ESI

What items are baseline requirement of ESI? What matters are most critical when choosing suppliers / key partners? What organizational actions need to be done and how suppliers can help to ensure companies to achieve competition advance with ESI actions.

As a result presented FIGURE 13 of the survey, the most important issues in co-operation and supplier choices are: 1. high quality, 2. willingness to cooperate, 3. low price, 4. fast response time in design.

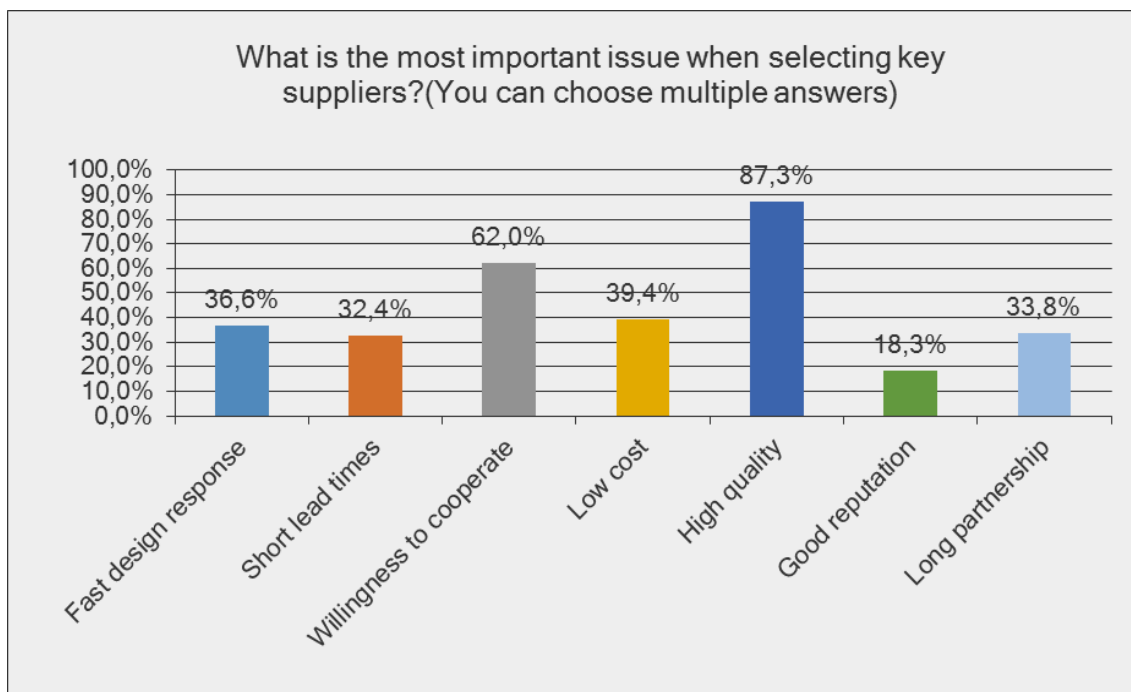


FIGURE 13. Main criteria's when selecting key suppliers

Respondents believe that the highest quality products and supplier willingness to cooperate most influence the choice of ESI partners. High quality components and high quality products are very important for the finished products in the field that the company manufactures and sells to its customers.

Almost half of the respondents thought that successful ESI projects would be a sourcing department responsibility as presented FIGURE 14. However, the conclusion of many studies is that the success of ESI projects should be in line with higher-level management responsibility and involvement. Successful ESI depends upon a high level of commitment and resource allocation from both the customer and supplier organizations. Senior management support in the provision of both financial and political resources is also critical. (Brown S, Eisenhardt K, 1995)

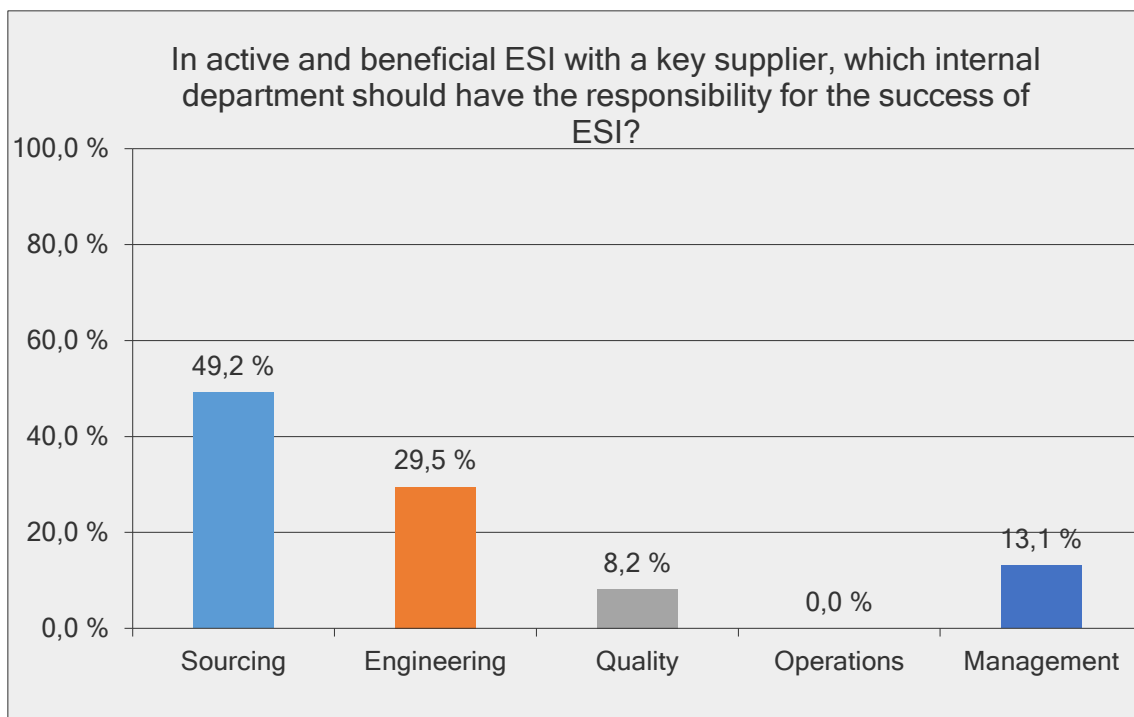


FIGURE 14. Responsibility of ESI success

Based on results from the survey more that 50% of the answerers feel that key suppliers strategic and critical items need to take into considerations much more in case company's design process. Key supplier knowhow and experience should be used always as a potential cost and time saving possibility in volume production if supplier proposals (i.e materials, process, and specifications tolerances) can be somehow followed in product design process. Results can be seen in FIGURE 15. Involving the suppliers early enough will led to significant benefits time, costs, and quality and product performance. (Trent 2007, 227)

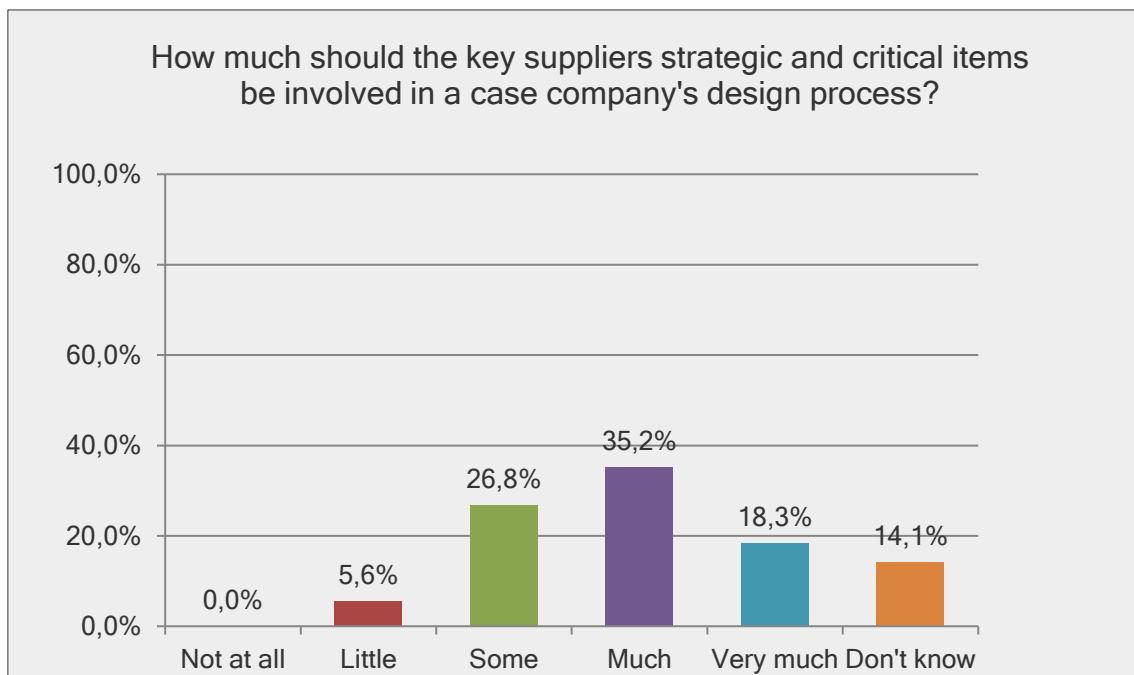


FIGURE 15. Key suppliers strategic and critical items

It is not enough that suppliers will be taken into product design early enough but requirement of the design need to be clarified and defined together with supplier to gain common understanding immediately when launching new design or new process. As seen from FIGURE 16 over 26% of the responders thinks that new product design requirements have been specified too poorly.

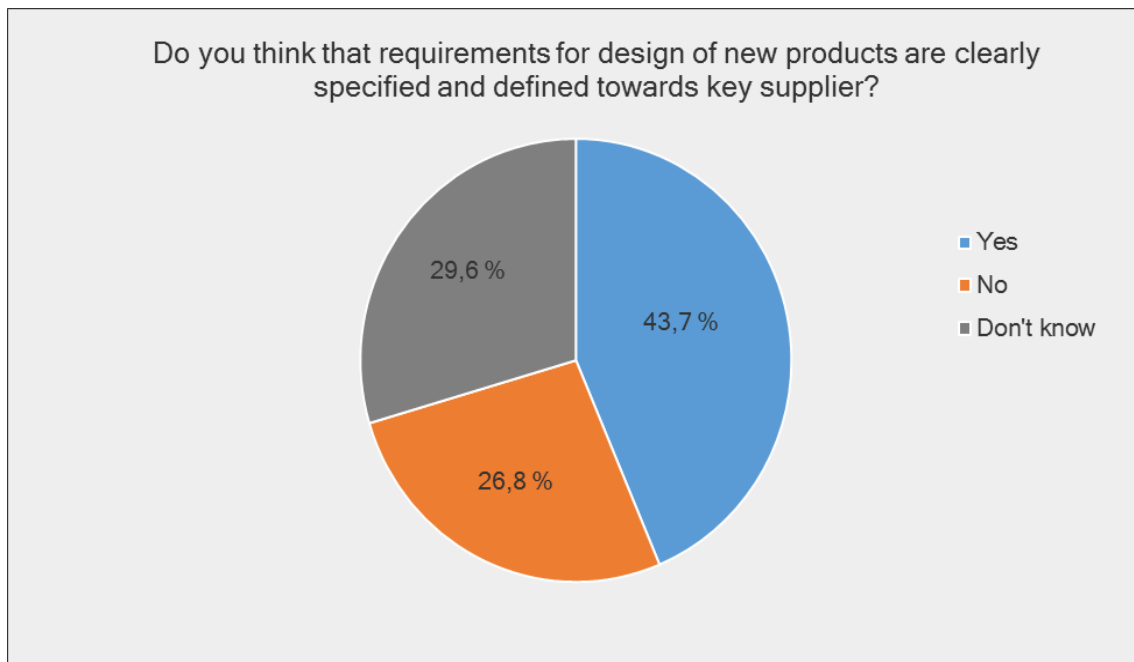
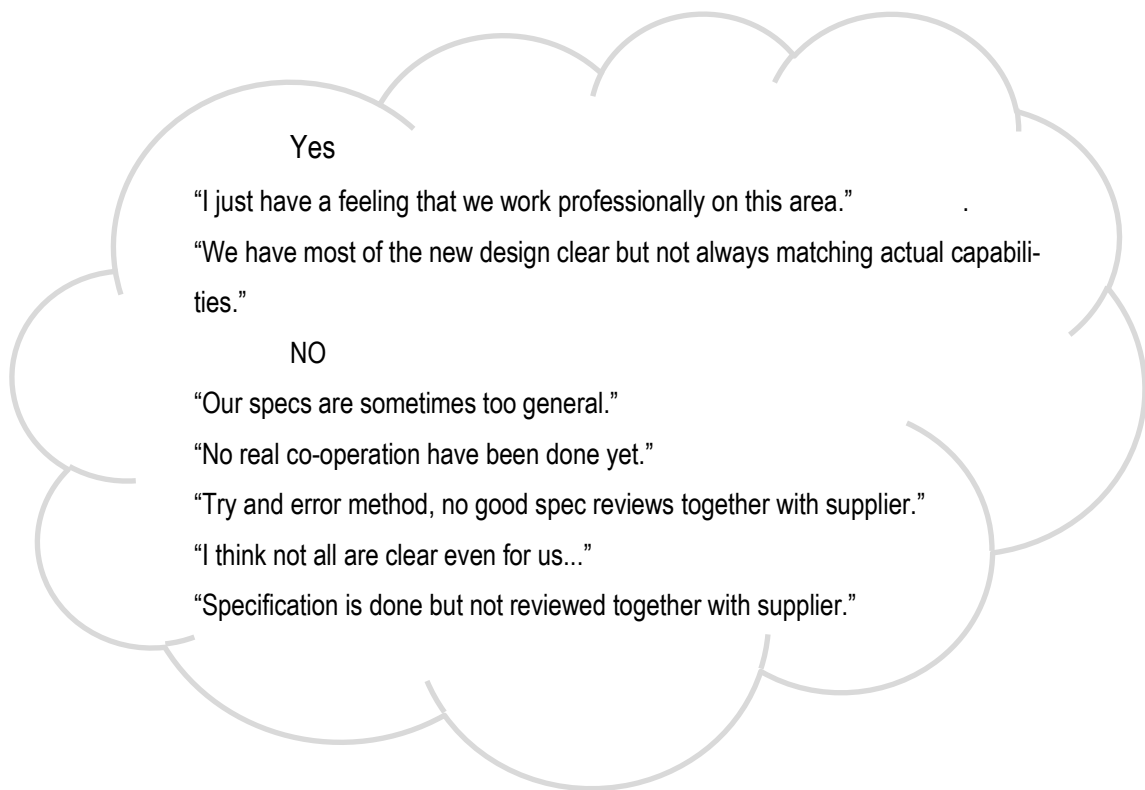


FIGURE 16. Requirements of new design

Examples of respondents yes and no responses in Figure 17 when they were asked opinion from clearly specified new product design requirements towards to supplier.



*FIGURE 17. Open question responds related to clarity of specifications*

More than half of the respondents felt that the requirements submitted to the suppliers were not sufficient or did not know that the requirements were sent to suppliers at all.



### 3.6 Outcomes of ESI

This section summarizes the answers to the questionnaire on what the respondents think of the results of the ESI process. Both benefits and disadvantages are presented, in addition, opportunities and threats are included in the responses based on respondents open answers.

#### 3.6.1 Benefits and opportunities of ESI

On the basis of both the replies to the questionnaire and the findings of the literature and the results of previous studies, it can be concluded that the benefits of ESI are undeniable. The price of purchased products is expected to drop, quality is expected to improve, both in design lead times and volume production manufacturing times is expected to shrink.

FIGURE 18 shows that most of the answerers thought that involving suppliers in company's new product development early enough will decrease the costs a little or will decrease the costs a lot. This advantage of lower product prices when involving suppliers early enough can be seen one of the most important reasons to implement ESI process to companies. (McIvor R, Humphreys P 2004, 179-199)

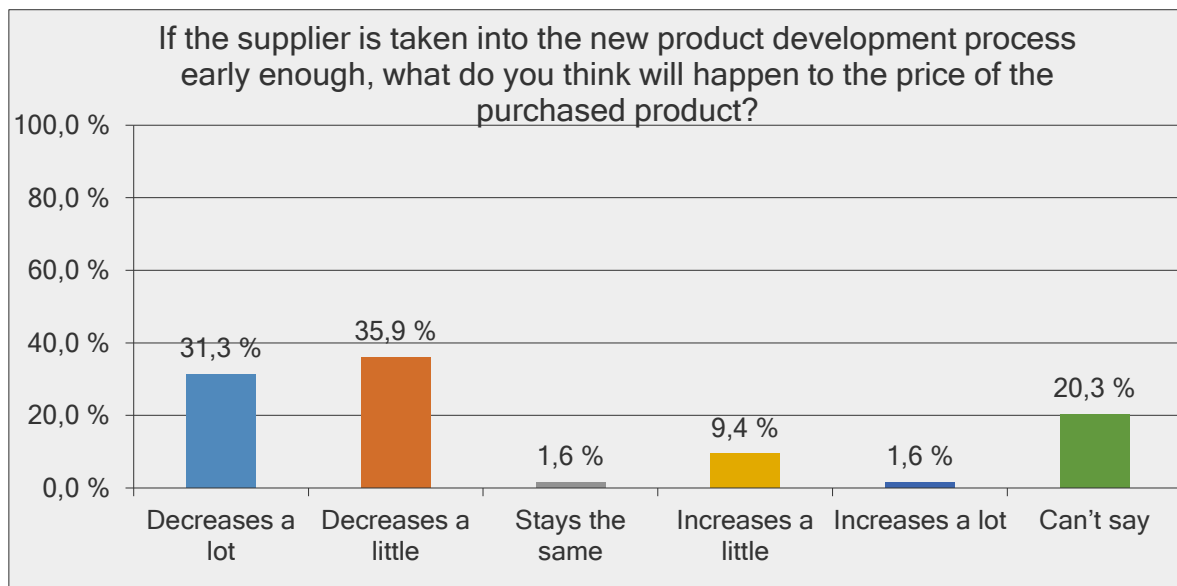


FIGURE 18. Price expectation of the products

As seen from FIGURE 19 over 90% of respondents agree that quality of products will improve a lot or at least a little when utilizing ESI process effectively when start to do new designs. (Ragatz G.L. et al. 2002, 389–400)

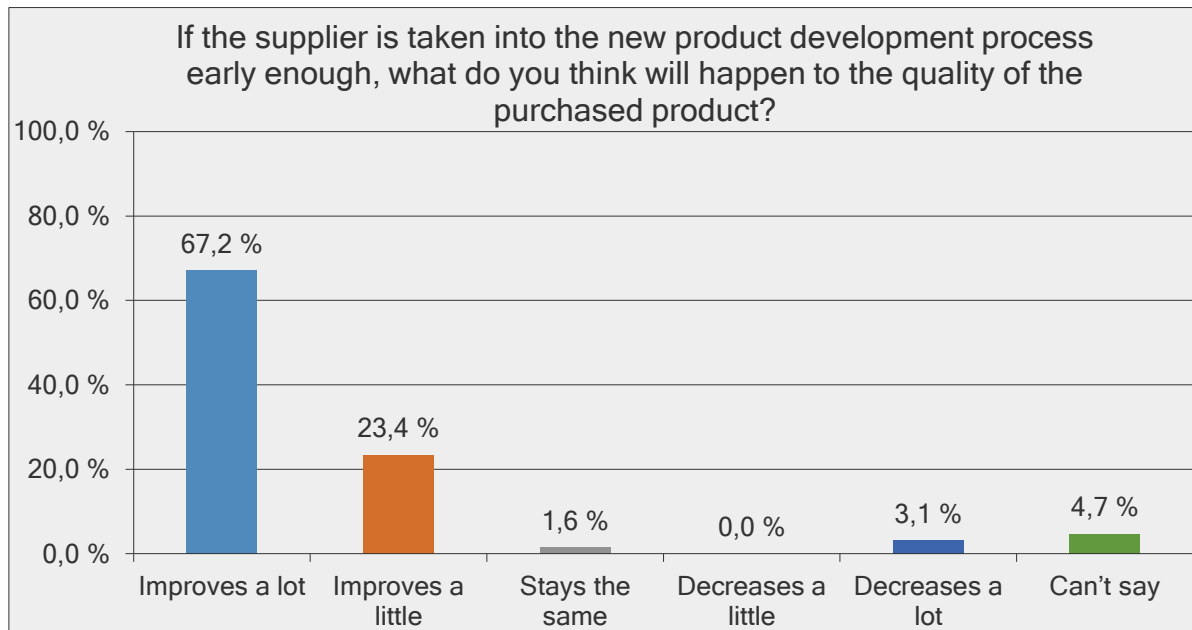


FIGURE 19. Quality expectation of the product

Almost 90 % of all answerers think that project lead-time will be shorten a lot or will be shortened; a little when involving suppliers early enough FIGURE 20. This gives the image that the personnel's attitude is positive towards the supplier integration but they are not waiting too much from it. Most positive answers were given from purchasing and R&D.

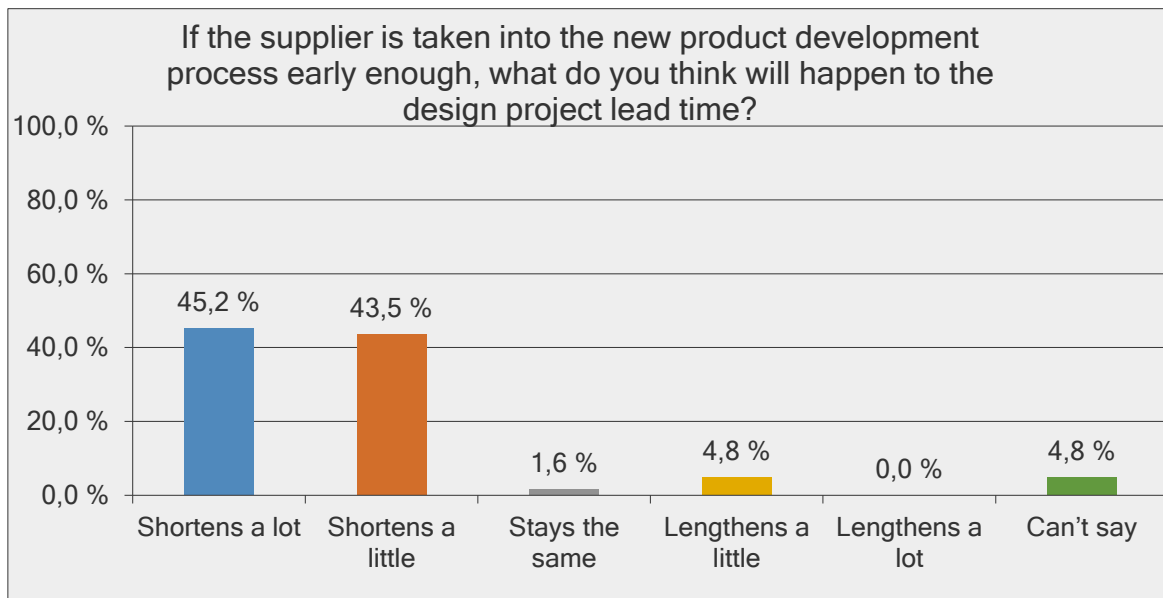


FIGURE 20 Design lead-time expectation of the product

### 3.6.2 Threats and weaknesses of ESI

The questionnaire also identified what weaknesses and threats could possibly be generated in a tight and open ESI. Weaknesses and threats were found both internally and externally with ESI partners.

As an opportunity to implement the ESI process in the NPD process, productization of demanding designees at one time. The choice and long-term cooperation of strategic suppliers contributes to the development of new products and to better quality standards in both proto and mass products. (TABLE 3)

As shown in TABLE 3, weaknesses include the small size of a business among large suppliers, the lack of resources and cost analysis, the lack of systematic ESI process management and ESI activity management.

The threats in the ESI process are seeing the leak of expertise and product information to competitors as well as the possible contraction of the supply field. It is also felt that the new process increases paperwork without providing real benefits, in which resources and roles would be clear and well-described. (TABLE 3)

TABLE 3 SWOT of ESI

Strengths	Weaknesses	Opportunities	Threats
Deeper co-operation with suppliers, better pricing from the start, better knowledge from their expertise areas.	Case company is too small customer for our suppliers, not enough resources to run effective ESI.	Suppliers can identify opportunities to reduce costs for the customer at earlier stages when involved at the beginning of the development process.	Has a risk to become just another paper without making a concrete change in company's roles and responsibilities in practice.
Forces company to think strategic supplier management and set the roles and responsibilities.	Supplier management strategy; responsibilities and practices are unclear.	Win more business from our competitors, competitive products with correct prices.	Information leakage, low cost hunt to lead to lower quality.
Improved sourcing and purchasing functions.	Lack of cost analysis and negotiation capability.	Doing design in first time successfully.	Some competitors are also suppliers.
Deeper co-operation more commitment from supplier.	Mindset that we can do everything better in-house.	Reduce product lifetime cost by selecting strategic suppliers and strong co-operation with them.	Makes it harder to change suppliers, so the selection should be done carefully.
Decrease of development costs, development time and product costs as well as an increase of product value and quality.	We are relative small customer for some suppliers, low volumes.	Higher volume product using same process platforms.	Could also result in increasing the development costs. Becoming depended on the supplier. Development engineers could feel threatened when supplier involvement is introduced.

### 3.6.3 Customer engagement to ESI

Other aspect from the questionnaire was to find out how to different organizations and people inside of the organizations see case company's customers in ESI process.

Based on responses of the questionnaire (FIGURE 21) awareness of the case company's competencies and capabilities should be increased and strengthened towards to key customers.

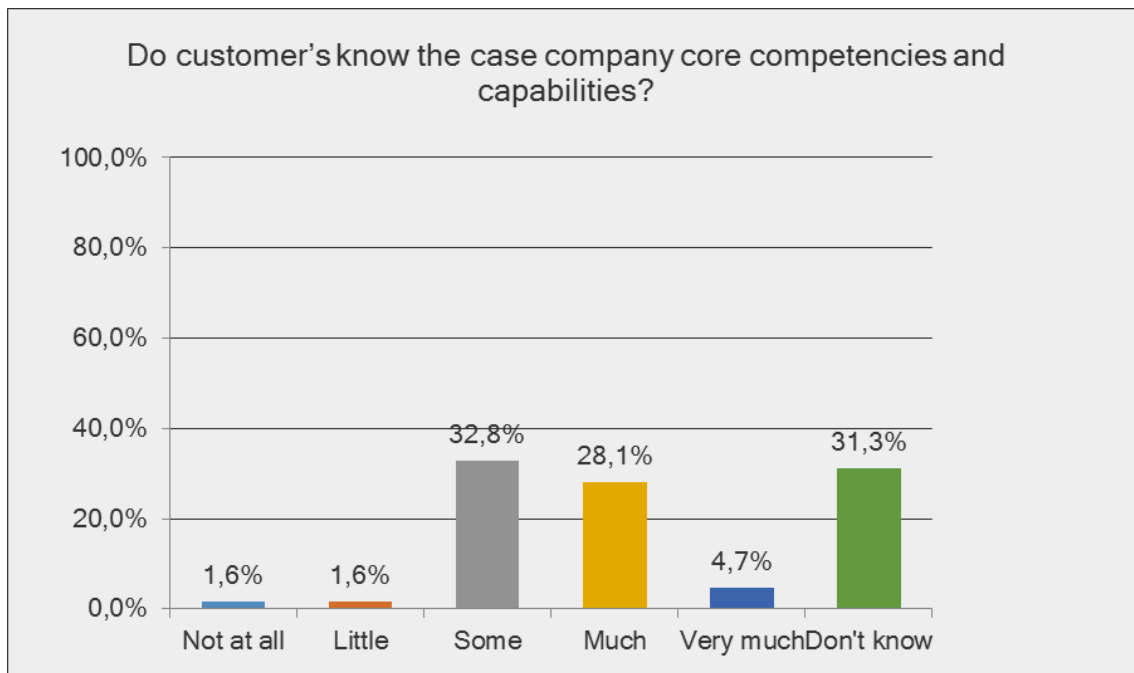


FIGURE 21 Customers knowledge of core competencies and capabilities of the case company

It can be clearly seen that customers find the case company as a strategic partner and key supplier (FIGURE 22) but they are not utilizing systematic ESI process with case company when creating /designing/developing new products or product processes.

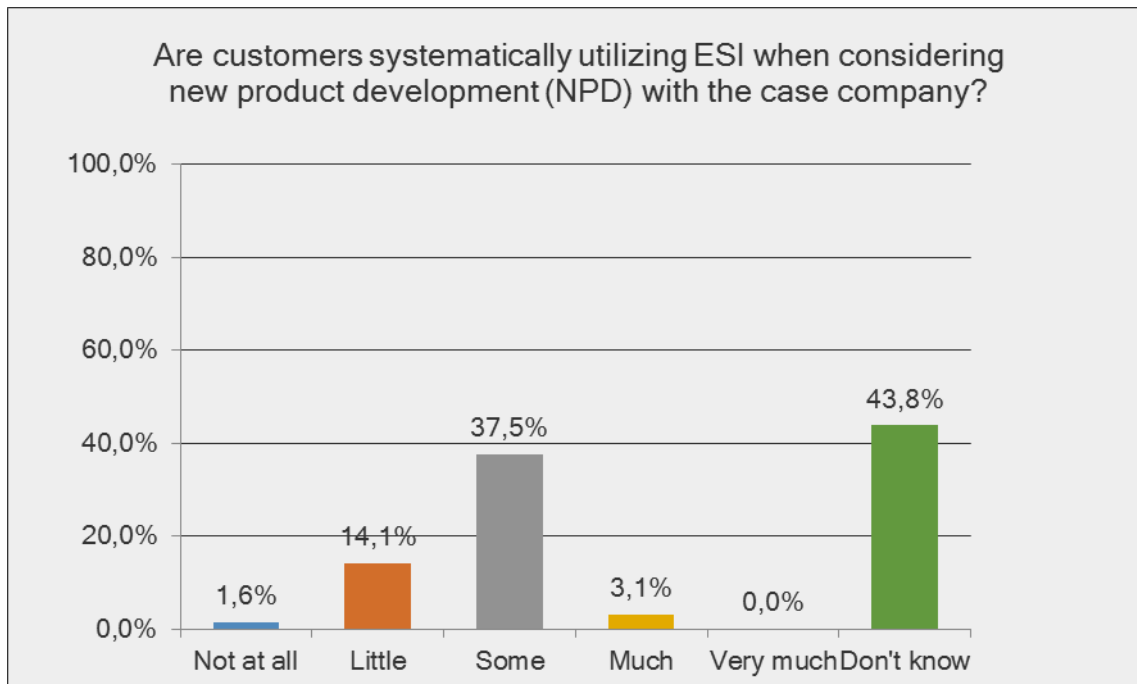


FIGURE 22 Customer's ESI activities / requirements with case company

As FIGURE 23 presents from product roadmap's point of view, either the case company or its customers are not very actively sharing roadmaps and this is clearly one reason why ESI process is not working as effectively as it could be. It would be extremely important to get ESI process working effectively at least with the biggest customers too.

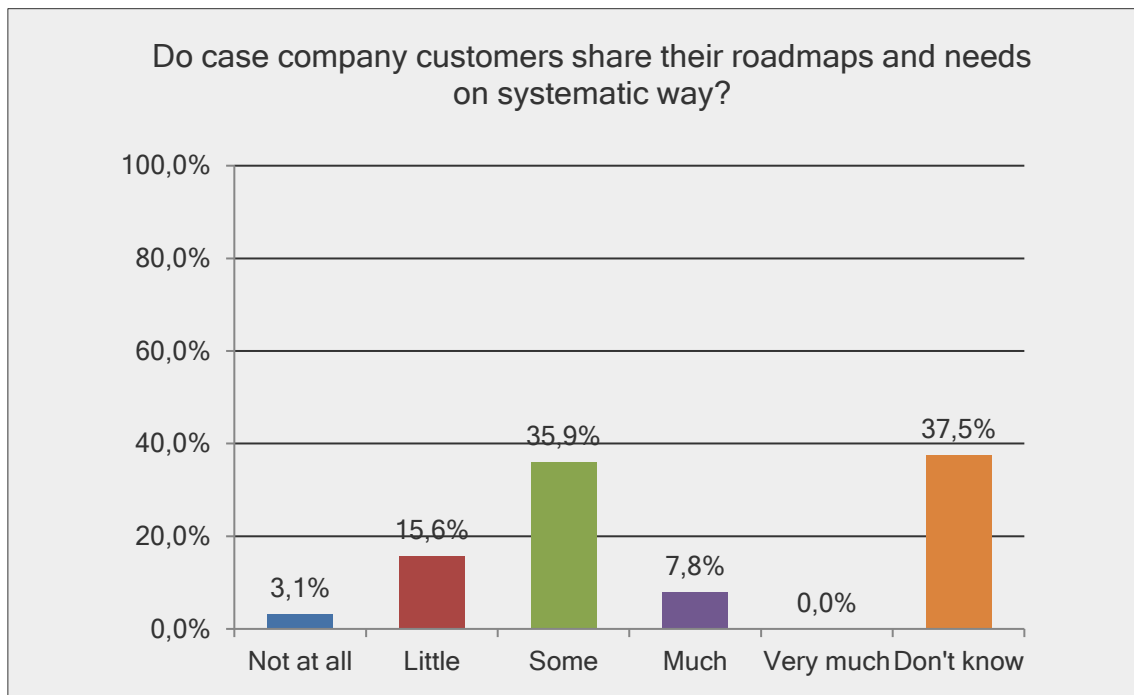


FIGURE 23 New product road map availability of the case company customers

It would be good for customers to get involved in thinking where a customer-supplier relationship would be based on collaboration that would be initiated at the conceptual stage as well as win-win thinking that achieves competitive advantages for which both the customer and the supplier are thriving in an ever-accelerating competition. As shown in FIGURE 24, the customer's requirements for the supplier's product development and supplier's production can be added specific value from 60 to 80% of suppliers' ESI activities.

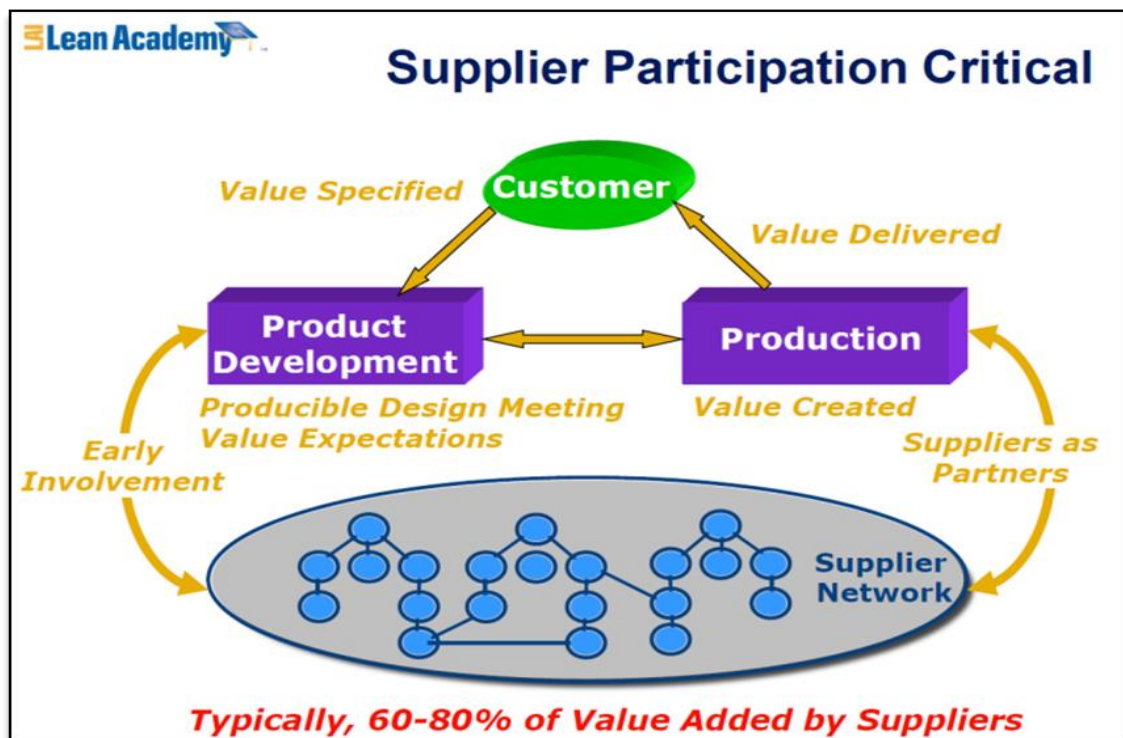


FIGURE 24 Customer-Supplier participation by Lean academy

As Parkkinen (2012) mentioned in his thesis ESI creates value by providing multiple benefits for both the supplier and the customer. Thus, these benefits are the value that is (co-)created in the co-operation when supplier provides its capabilities to be used in the customer's product development process. Value is created for both the supplier and the customer, and the actualized value depends on the wider value creation context of the party for which it is created. This basically means that the gained benefits have differing value according to the interpretation of that value made in the context of a specific company. Resulting from this, the general benefits gained from ESI cooperation can be listed (TABLE 4), but the actual value created can specifically be interpreted only in the context of a specific company.



TABLE 4 Value created by ESI

Value created by ESI	
Supplier	Customer
Privileged treatment by customer	Shorten development time of product
Access to customer's technical capabilities	Reduce cost of product
Enhanced financial performance	Improve quality of the product
Enhanced reputation	Access to supplier technical capabilities
	Possibility to influence supplier's future technology

## 4 CONCLUSIONS

In this research, there were three main objectives to focus on, firstly to identify key success factors and define key responsibilities of ESI. Secondly, to define ESI process and give guidelines and tools for executing ESI process in a systematic way. Thirdly, to analyze different implementation alternatives of ESI inside of the case company's new product development process.

Following the analysis of the responses to the questionnaire, a conclusion was made to create a formal ESI process. Success factors of ESI were recognized easily from both studied materials and from results of the questionnaire. Background work and questionnaire survey identified the most important process steps and responsibilities for creating an ESI process in the company.

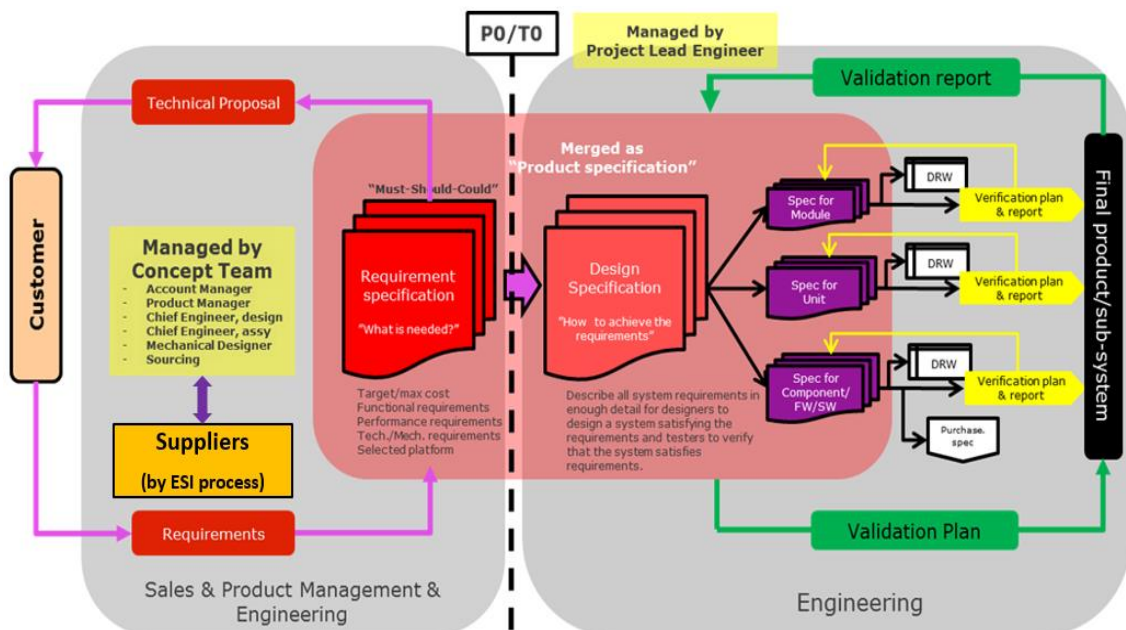


FIGURE 25. ESI process implementation to company new product development process

The ESI process was decided to involve the development process of the new product already in the conceptualization phase of new products.

As FIGURE 25 shows ESI process is heavily linked to multi organizational, team (Concept Team) which includes senior level professionals from different organizations from the company. Among the other tasks the purpose of the concept team is to find out / describe any ESI needs; either

based on new customer requirements, own product development needs, or company own future road maps. After potential ESI categories have been agreed ESI process will be launched.

The ESI process which has been described in FIGURE 26. Figure shows process steps which should be managed and executed during agreed schedule to achieve benefits which have been presented earlier in this thesis; Shorten product design lead time, improve product quality, reduce product development costs and improve product manufacturability.

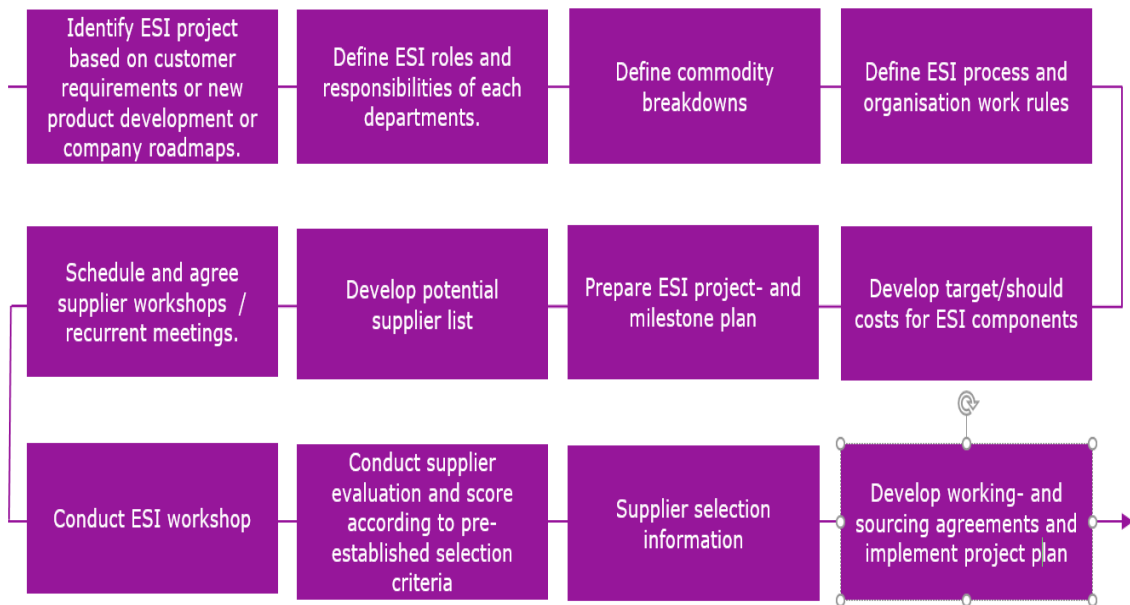


FIGURE 26 Created ESI process of case company

Based on the questionnaire and analysis of its results three main process steps were categorized as more important ESI activities than rest of them.

#### 4.1 Define ESI roles and responsibilities

Each technology area should have a counterattack in the supplier organization that owns the development of a new product. Just ownership of the matter is not enough but the necessary competence and know-how must also be. In technical matters, usually an engineer organization is responsible for the supplier, whereas in commercial affairs the sourcing organization assumes re-

sponsibility for suppliers. Quality assurance of suppliers in ESI is provided by sourcing quality engineer. => ESI will not work and will not get the benefits if the organization does not make enough resources for the knowledgeable resources.

As FIGURE 27 shows technical and design responsibility is shared clearly between a case company-engineering department and supplier technical counterpart.

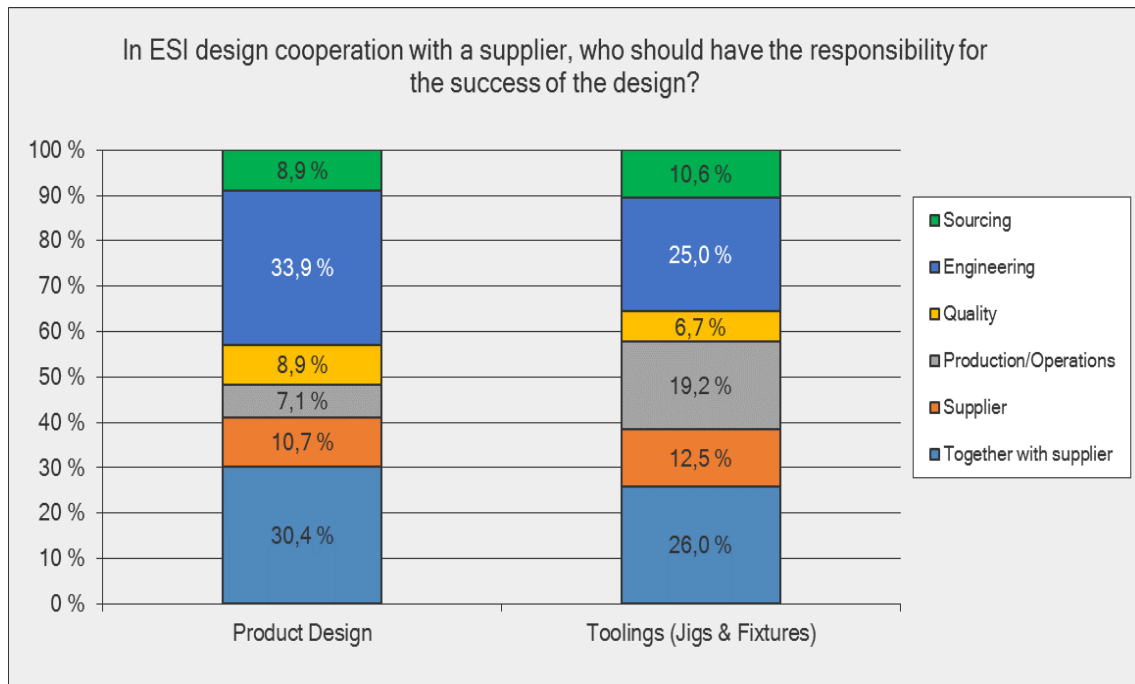


FIGURE 27 Responsibility of technical designs

A culture in both the buyer and supplier organization must exist in order to facilitate and encourage joint problem solving and decision making across intra-organizational boundaries. The findings have stressed the need for a culture that breaks down the internal barriers that exist within the traditional functional view of the firm. It is not enough to change the attitudes of the purchasing personnel but the attitudes of the other business functions and senior management must be changed in the pursuit of collaborative buyer–supplier relations. It requires a culture permeating the organization hierarchy that encourages and values collaboration

ESI requires a cultural change within the buyer and supplier organization where there is enhanced understanding of the concept of collaboration. It is acknowledged that effecting culture change is

often regarded as being a huge task, which is made even more difficult by the deeply embedded culture that has evolved over a long period of time. (Cadden.T, Downes.S.J, 2013)

From sourcing management point of view responsibility of commercial issues and lead-time issues are managed by sourcing FIGURE 28

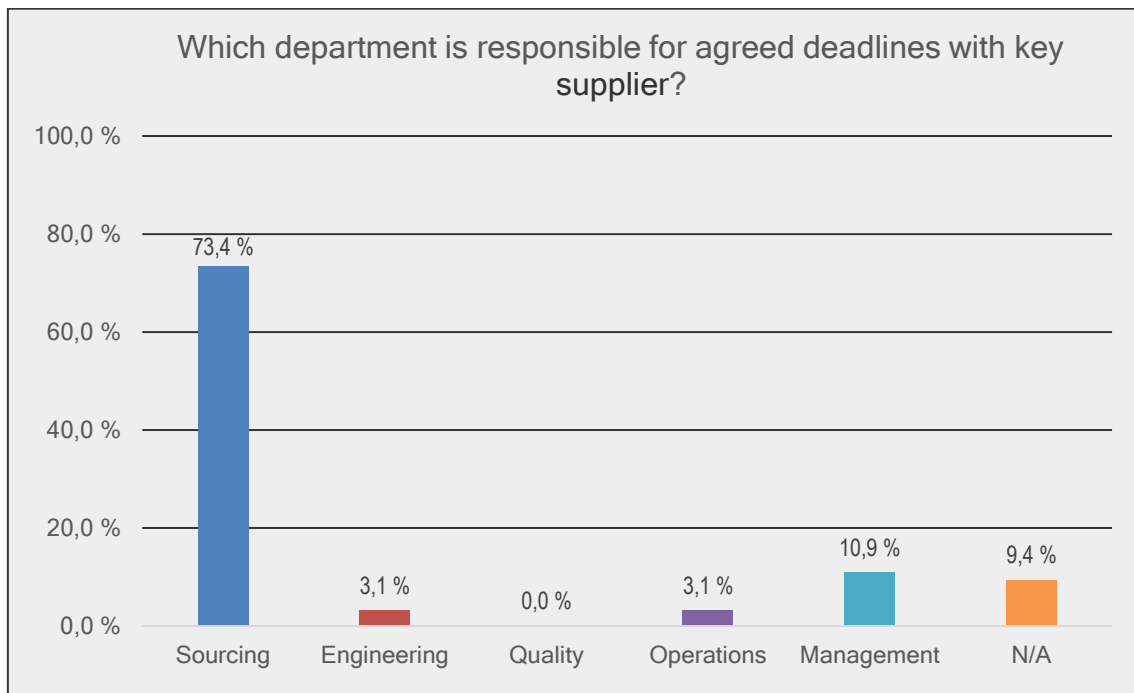


FIGURE 28 Responsibility of commercial deadlines

## **4.2 Define ESI process and rules**

A large part of the unfulfilled potential of ESI is due to common problems such as lack of communication and trust, insufficient supplier abilities and willingness and internal resistance at the manufacturer.

First, the necessary activities and processes for different Early Supplier Involvement areas need to be defined. Secondly, introduce and understand both own company's design- and process capabilities and supplier's capabilities to improve design and achieve shorter lead times, cheaper costs and improved quality. Thirdly, define case company's design rules, which are available to persons in customer interfaces.

It is easy to see the benefits of early supplier involvement compared to the traditional method of engineering, procurement, and construction (EPC). Instead of being presented with a list of predetermined elements, ESI helps to create that list as the design evolves. ([www.pmiquality.com](http://www.pmiquality.com)) Suppliers can suggest process changes that would lower the production lead-time or remove steps altogether for substantial cost savings. The risk, however, is that these recommendations can compromise the integrity of the design.

### **4.2.1 Specifications**

Depending on the design of the product, an engineer could be faced with any number of tasks when it comes to defining for example material specifications. Any given product may need to have different kind of process, quality and environmental requirements like heat-resistant, electrical conductivity and twisting stiffness. There are a number of different ways to solve this solution, but the simplest way is to involve a supplier, the specialist. Since a supplier has knowledge and expertise in their materials, a designer simply presents them with details of what's needed and in turn receives the best possible alternatives.

#### **4.2.2 Tolerance chains**

Engineers can also often be “cautious” of setting unrealistic expectations when it comes to tolerances on their designs. This is by no means a fault, just a combination of wanting complete control of their design and misinformation on the manufacturing processes. By utilizing ESI, the supplier’s expert can go through each manufacturing process and explain how feasible the suggested tolerances are. If a forming method is non-crucial, then loosening of the tolerances speeds up manufacturing time and lowers cost in the process and it will lower the final price of purchased part/product. ([www.pmiquality.com](http://www.pmiquality.com))

#### **4.2.3 Process changes**

Generally, the biggest reason to have ESI is for any process changes that may need to be completed on a design. ([www.pmiquality.com](http://www.pmiquality.com)) The “old way” of design involved three steps: 1) engineering, 2) procurement, and 3) production. The supplier was not involved until after a design had been modeled and numerous prototypes had been manufactured. Once a design had been finalized, the responsibility of finding the most cost effective ways of production fell to the procurement department within a company.

The changes effected by ESI phase at the very heart of the organization and have implications for the way in which an organization is structured, individual roles, responsibilities, reward systems and reporting relationships. The changes are systemic in that modification to structural arrangements for example, automatically has an effect upon individual roles, responsibilities, reward systems and reporting relationships. It is essential to ensure the adoption of a holistic approach to managing the entire process. The findings highlight a number of lessons for organizations that are considering the adoption of ESI. (McIlvor R, Humphreys P, Cadden T, (2006)

#### 4.2.4 Supplier selection

Three main factors can be described when discussed efficient supplier selection as presented in FIGURE 29. The first is supplier selection processes. The early involvement of suppliers, already during conceiving phase is important but it need to be remember that involving all suppliers are not essential but the right suppliers are. The second factor is the need of for supplier relationship development and adaptation which includes multiple actions/tasks for both buyer and supplier organizations. The third factor involves the internal capabilities of the customer like top management commitment and internal cross-functional coordination (Johnsen T.E. 2009). All of these three success factors have been also found very important roles of key supplier involvement of the case company.

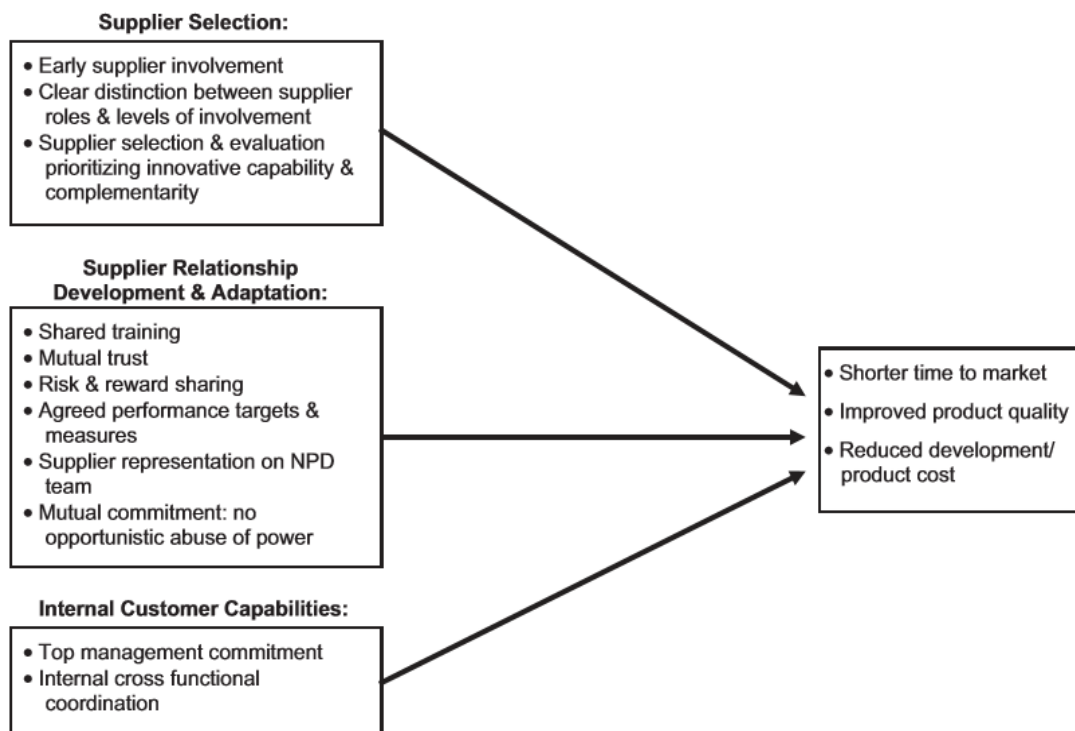


FIGURE 29 Factors affecting supplier involvement success by T.E. Johnsen 2009



### **4.3 Develop and define target/should cost for ESI parts/components**

Continuous cost follow-up and seeking cost information from suppliers are important processes that support and help ESI activities. Understanding the product's material and labor costs is an essential part of product development process and future cost reduction possibilities.

A case company should build up a database or other systematic approach where the history of purchased parts, lead times, and designs can be found as a reference of new produced part to understand suppliers' and their processes. All new designs should be benchmarked using existing price data from the database and understand possibilities for cost saving. In addition to the above-mentioned internal actions, at the same time, a "real cooperation model" should be built with the selected mainstream suppliers.

## 5 DISCUSSION AND FUTURE RESEARCH

The case company found that a well-derived and systematically implemented ESI lacked a new product development process. The ESI process was not taken into account as a major sub-process in the product conceptualization phase. Possible benefits of the ESI were well recognized, but a disciplined and continuous process with its officers was somewhat new in the company.

The Survey, literature findings and previous studies clearly show that an efficient and systematic use of ESI helps to shorten the design lead-times of new products, reduce the price of purchased parts and improve product quality. Identifying and planning the ESI process in companies requires both responsibility and responsibility sharing (TABLE 5). Every new product development product, material, process that wants to achieve results faster, cheaper and better, must have a clear roles and responsibilities, the participants have the know-how needed to solve the challenges and requirements ahead. In addition, it must be possible, for example, to challenge suppliers for prices and materials. The company must have specialists who have an understanding of supplier chains, prices, manufacturing processes, tolerance chains and specifications. With these capabilities and expertise, the company can estimate the cost structures of future products in advance.

TABLE 5 Reasons to implement ESI process.

<b>Should ESI process to be implemented and why?</b>
Yes, it should be implemented with key suppliers who sell us the most important components plus components which have the highest quality risk.
Yes, this will sure increase the success rate of PC projects.
Sure. If ESI strategy is well executed, it can result in a shorter project cycle-time, a lower price of parts, and fewer quality problems. However, case company should consider when and to what extent a supplier should be involved, next to the capabilities and culture of the supplier.
I think it is necessary, because it can provide us to learn more from the suppliers and design new products with more optimized processing, materials and really can short the time from design to marketing.
Yes, definitely, ESI will improve DT's Tech knowledge to better serve case company's customers, and strengthen the relationship with suppliers, more important to avoid the potential risk from the process handling and improve the cost efficiency.
I see more heavy involvement of the main suppliers as benefit, and should be implemented. Just to make sure that the design of the process is done well, so that when taken in use it works well, effectively, reaches objectives what are set to it (cost, lead time, quality improvement etc.) and that supplier really sees this improvement and feels that it is mutual improvement into way of operating.

Usually, when ESI is spoken of the positive consequences and opportunities of the process are mainly identified. More specifically, the negative aspects and threats of the ESI process may be limited by open and long-term co-operation with the key suppliers

To achieve the benefits associated with ESI it is essential that all of those who are involved are committed to the company strategy. This must be supported by an organizational program which aims to enable individuals to acquire and develop skills, behaviors and attitudes which facilitate the implementation of the strategy. It is essential that both the buyer and supplier organizations identify the range of skills, behaviors and attitudes, which are critical to support effective ESI collaboration. The benefits of the ESI process and its disadvantages are seen only after several years of cooperation. For example, in the company involved in the research, the development times for new products can range from six months to 18 months, so the real benefits of the ESI process can be seen in 2-3 years after product development. For this reason, the "counterparts" of the real ESI process should be carefully chosen for partners who really want to engage in a long-term product development and win-win business relationship, whose aim is not merely a profit-seeking quest.

Keeping and developing the ESI process requires senior management commitment, strong rollout, and above all a lot of work to make the ESI process a part of everyday, normal business practice. One of the cornerstones of the new product development process of the company should be ESI, whose benefits and positive impacts are undeniable, and the proper use of it gives competitiveness throughout the industry. "Within the organization, strategy has been formulated by a small team of senior managers, more or less in isolation from those whose support is a vital ingredient for implementation. Furthermore, it has been formulated by a team who are often perceived to make decisions, which display a lack of knowledge and understanding of working processes, practices and relationships throughout the organization, or of the implications of their decisions in terms of support structures necessary to facilitate implementation," indicates McIvor, Humphreys (2004). Thus, considering the inter- and intra-organizational implications of ESI, it is essential that organizations pursue a much more participative approach to the strategy making process. At the same time, senior management need to exercise what Brown and Eisenhardt (1995) describe as subtle control. This term refers to the ability of senior management to have the vision necessary to develop and communicate a distinctive, coherent concept of the product. As mentioned by Cadden and Downes (2013) senior management has a critical role to play in facilitating ESI. Within the organization at the core of this paper, strategy has been formulated by a small team of senior managers, more or less in isolation from those whose support is a vital ingredient for implementation. In the case of

product development, this means meshing firm competencies and strategies with the needs of the market to create an effective product idea.

After the implementation of the ESI process, it would be useful to study the real cost implications of both direct and intermediate production costs. This study enables life cycles of the industrial products concerned, which can well reach the age of over 10 years. The development of both costs should be monitored; in new project phase and in new products in production phase. In the future, it would be also good to study the impact of the actual ESI process on the basis of the early needs/product road maps of the main customers.

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## SURVEY QUESTIONS

APPENDIX 1 (1)

1. In Which organization/department you are working in the company.

- Business Unit (BU)
- Engineering
- Sourcing
- Purchasing
- Quality
- Production/Operations
- Management
- Other (please specify)

2. In which country/premises you are working for the company.

- F (Finland)
- M (China)
- B (China)
- US (USA)

3. How many years have you worked for the company?

- 0-1 years
- 2-4 years
- 5-7 years
- 8-10 years
- >10 years

4. How much do different departments co-operate in the company (BU's, R&D / Engineering, sourcing, quality, and production/operations)?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

## SURVEY QUESTIONS

APPENDIX 2 (1)

5. How much cross-functional design work is done in the company?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

6. How much do you know about company's key suppliers' basis (turnover, location, personnel, product portfolio, capabilities etc.)?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

7. According to your knowledge, how much do we know about key suppliers new material development processes?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

## SURVEY QUESTIONS

APPENDIX 3 (1)

8. According to your knowledge, how much design cooperation has been done earlier with the key suppliers in the company?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

9. From your point of view, what is the most important design area where key suppliers should cooperate together with DT? (You can choose multiple answers)

- Photo diodes
- Printed circuit board substrate
- Printed circuit board assemblies
- Ceramic substrate
- Scintillators
- Application Specific Integrated Circuit (ASIC)
- Tools (jigs & fixtures)
- Testers
- Other (please specify)

10. How much have case company key suppliers done initiative design improvements?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

## SURVEY QUESTIONS

APPENDIX 4 (1)

11. How much should the key suppliers strategic and critical items be involved in case company design process?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

12. How much do key suppliers know about material quality planning (customer requirements -> PFMEA & DFMEA -> Quality Control Plan)?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

13. How much do company's sourcing engineers / purchasers know about the parts they are buying (design- & technology requirements, tolerances, materials, etc.)?

- Not at all
  - Little
  - Some
  - Much
  - Very much
  - Don't know
  - Yes / No / Don't know
- If your answer is yes or no, please describe why

## SURVEY QUESTIONS

APPENDIX 5 (1)

14. Do you think that requirements for design of new products are clearly specified and defined towards key supplier?

15. What does "case company" want from the supplier when doing design cooperation with them?

16. How much do you think that designers know about the cost factors of their designs?

Not at all

Little

Some

Much

Very much

Don't know

17. What do you think is the most expensive material usually in case company product Bill of Materials (BOM)?

Photo diodes

Ceramic substrate

Printed circuit board substrate

Printed circuit board assemblies

Application Specific Integrated Circuit (ASIC)

Scintillators

Don't know

18. What is the most important issue when selecting key suppliers? (You can choose multiple answers)

- Fast design response
- Short lead times
- Willingness to cooperate
- Low cost
- High quality
- Good reputation
- Long partnership

19. From your point of view, how would you describe current development processes in case company?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know

Product Creation (PC)

Product Modification (PM)

Technology Creation (TC)

## SURVEY QUESTIONS

APPENDIX 7 (1)

20. How would you describe the sourcing department capability to commit the key supplier to case company's new product development- / Early Supplier Involvement (ESI) processes at the moment?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know

21. How would you evaluate the sourcing department's current resources (time, number of personnel) to engage a supplier into the company's new product development- / ESI processes?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know

22. How would you evaluate the engineering department's capabilities to do design collaboration with a supplier at the moment?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know

## SURVEY QUESTIONS

APPENDIX 8 (1)

23. How would you evaluate the engineering department's current resources (time, number of personnel) to do design collaboration with a supplier?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know

24. How would you evaluate the quality department's current resources (time, number of personnel) to do design collaboration with a supplier?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know

25. How would you evaluate the sourcing department's motivation to collaborate with the engineering and quality departments to achieve the objectives in ESI?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know



## SURVEY QUESTIONS

APPENDIX 9 (1)

26. How would you evaluate engineering department's motivation to collaborate with the sourcing and quality departments to achieve the objectives in ESI?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know

27. How would you evaluate the quality department's motivation to collaborate with the sourcing & engineering departments to achieve the objectives in ESI?

- Very Bad
- Bad
- OK
- Good
- Excellent
- Don't know

28. In ESI design cooperation with a supplier, who should have the responsibility for the success of the design? Product Design / Toolings (Jigs & Fixtures)

- Sourcing
- Engineering
- Quality
- Production/Operations
- Supplier
- Together

29. How should the communication happen between the case company and the key supplier? Who is doing and what?

- Sourcing
- Engineering
- Quality
- Production/Operations
- Management

30. Which department is responsible for agreed deadlines with key supplier?

- Sourcing
- Engineering
- Quality
- Production/Operations
- Management

31. In active and beneficial ESI with a key supplier, which internal department should have the responsibility for the success of ESI?

- Sourcing
- Engineering
- Quality
- Production/Operations
- Management

## SURVEY QUESTIONS

APPENDIX 11 (1)

32. According to your knowledge, what are the design core competencies of the case company?  
(Evaluate design abilities in different functional groups as following)

Very little knowhow, suppliers help necessary

Little know-how

Good know-how

Very good knowhow

Excellent knowhow

Don't know

Photo diodes

Scintillators

Printed Circuit Boards

Surface-mount device (SMD)

Application Specific Integrated Circuit (ASIC)

Conductive glues

Tools (jigs & fixtures)

Testers

33. In which design phase do you think each department should step into the design process for the first time?

Engineering

Sourcing

Purchasing Quality

Production/Operations

Sales

Logistics

Management

34. Based on your knowledge, company's supplier selection criteria mainly consist of..

Completely operative issues such as current price

Mainly operative issues and requirements in near future

Balanced mix of operative issues and long term requirements

Mainly strategic issues (supplier's technological know-how,technology road-map,future perspective..)

Completely on strategic reasons/issues

35. If the supplier is taken into the new product development process early enough, what do you think will happen to the price of the purchased product?

Decreases a lot

Decreases a little

Stays the same

Increases a little

Increases a lot

Can't say

36. If the supplier is taken into the new product development process early enough, what do you think will happen to the quality of the purchased product?

Improves a lot

Improves a little

Stays the same

Decreases a little

Decreases a lot

Can't say

37. If the supplier is taken into the new product development process early enough, what do you think will happen to the design project lead time?

- Shortens a lot
- Shortens a little
- Stays the same
- Lengthens a little
- Lengthens a lot
- Can't say

38. In which design phase you think that supplier should be involved in the new product development process for the first time?

- Definition of design requirements
- Concept creation
- Initial design
- Actual design
- Complementary design
- Finishing design
- Prototype phase

39. Are case company's customers systematically utilizing ESI when considering new product development (NPD) with case company?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

## SURVEY QUESTIONS

APPENDIX 14 (1)

40. Do case company's customers know its core competencies and capabilities?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

41. Should case company share capabilities and roadmaps for customers more actively?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

42. Do case company's customer share their roadmaps and needs on systematic way?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

## SURVEY QUESTIONS

APPENDIX 15 (1)

43. Is a case company considered as key/strategic supplier by case company's customers?

- Not at all
- Little
- Some
- Much
- Very much
- Don't know

44. What would improve ESI for case company's current/potential customers?

45. When involving suppliers early in the design process, what are the 3 most important factors to consider and the 3 most important mistakes to be avoid?

- Important 1
- Important 2
- Important 3
- Mistake 1
- Mistake 2
- Mistake 3

46. What are the strengths, weaknesses, opportunities and threats of case company in involving suppliers early?

- Strenghts
- Weaknesses
- Oppotunities
- Threats

47. Should ESI process to be implemented to a case company and why